MINISTRY OF AGRICULTURE AND FISHERIES
DEPARTMENT OF AGRICULTURE FOR SCOTLAND
MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND
AND AGRICULTURAL RESEARCH COUNCIL

REPORTS

on the work of

Agricultural Research Institutes

and on certain other agricultural investigations in the

United Kingdom

1932-1933

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LONDON
PRINTED AND PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses:
Adastral House, Kingsway, London, W.C.2; 120 George Street, Edinburgh 2;
York Street, Manchester 1; 1 St. Andrew's Crescent, Cardiff;
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1935

Price 5s. 6d. Net

24-130-0-33

This volume outlines the progress of agricultural research carried out with the aid of State funds during the Academic Year 1932-33 at Research Institutes and other centres in the United Kingdom. A numbered list of the papers published during the year by each Institute or research centre is appended to each report, and references to the numbers of these papers will be found in the text.

Those desiring further information regarding any subject dealt with in the reports should address their enquiries to the Director or other person concerned. A list of the names and addresses of Directors of Research Institutes and persons in charge of investigations at other centres is given in the Appendix (page 360).

Ministry of Agriculture and Fisheries,
10, Whitehall Place,
London, S.W.1.
1934.

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I

RESEARCH INSTITUTE INVESTIGATIONS

A

SOILS, PLANT NUTRITION AND PLANT PHYSIOLOGY

1. ROTHAMSTED EXPERIMENTAL STATION

The Soil.

(a) *Field Work.*

The value of organic manures as compared with artificial fertilisers.—Two long period rotations deal with the important problem of returning straw to the land. The old Norfolk method of making it into farm yard manure in the buildings during winter by the agency of fattening cattle has proved unprofitable: alternative methods were therefore tried. These treatments included:—

(i) straw made into farm yard manure in the old way;

(ii) straw ploughed direct into the soil, along with artificial fertilisers;

(iii) straw rotted artificially by the "Adco" process;

(iv) artificials only, without addition of straw or of any organic matter.

The experiments are intended to run for a number of years and are designed to bring out both the immediate and the long term effects.

Green manuring receives considerable attention as a practicable method of supplying organic matter to the soil. Earlier experiments show however that it is very liable to prove ineffective, and the present experiments are designed to discover the causes of the failure and the best ways of obviating them. So far fallow appears to be a better preparation for wheat than a green crop ploughed in, even a clover ley; this however was better than rye grass.

Poultry manure gave some interesting results. For ordinary agricultural crops it was usually inferior to artificials. For the market garden crops, onions and brussels sprouts, it was superior at some of the centres. The results show that the manuring of market garden crops should not necessarily follow the same schemes as are adopted for farm crops, and they indicate strongly the desirability of a proper investigation, planned on modern lines, to find how best to deal with them.

The effects of artificial fertilisers on the yield and quality of crops.—The key experiments in this investigation are those on the classical plots at Rothamsted and Woburn and on the more

recently established six course rotation which is intended to run for a long period of years. As, however, the effects are known to be modified by soil and season, experiments are made at outside centres on a carefully drawn-up scheme that enables us to collect in each season as much information as is practicable.

Barley.—Work on barley in association with the Institute of Brewing has been continued. The Report of ten years experiments has now been published (23).

Sugar Beet.—Experiments show that the present methods of manuring are unsatisfactory. The responses are much less definite than for potatoes or mangolds and the one consistent result is that although nitrogenous manuring somewhat lowers the sugar content it increases the yield to a greater extent and thus increases the sugar production per acre. Chemical examinations of the soils were made by various methods including one which is, we understand, much used by the advisory staffs of sugar beet factories for informing farmers what fertiliser they should use. This method showed low phosphate contents in several soils on which, nevertheless, beet failed to respond to superphosphate.

Yet there is clear evidence that sugar beet is not a starvation crop because its yields have varied in the various experiments from 6 to 16 tons per acre. The whole subject calls for much further attention that it has hitherto received. The average yield over the country is too low to enable the industry to be self supporting, and it is unreasonable to expect a subsidy to continue unless the fullest efforts are made to raise them. Sugar beet differs from all other crops in the very high concentration of its root sap which cannot fail to modify in some way or other the translocation of sugar from the leaf. A physiological study of the growing crop is needed before the manurial problems can be fully solved.

As the result of Conferences with the Sugar Beet Committee in March, 1933, a new type of field experiment was drawn up to test the response of typical soils to fertilisers in relation to the chemical composition of the soil. Thirteen fertiliser trials each with 24 plots of about 0·1 acre were laid down and soil samples taken in such a way as to provide independent checks on the accuracy of sampling and analysis. The experiments were on sites selected as being representative of the areas around each of thirteen beet sugar factories. As the sugar beet yields are not yet available it is not possible to discuss the relationships between yields and responses to fertilisers in the field trials and the analytical data obtained in the laboratories. The latter included (i) mechanical analyses, (ii) soil reaction, (iii) exchangeable bases, with separate determinations of calcium and potassium, (iv) carbonate, (v) readily soluble phosphate by three methods, (vi) readily nitrifiable nitrogen by two methods, (vii) readily oxidisable carbon, and (viii) total carbon and total nitrogen.

Some similar analyses were made on a series of soils from the experiments of the previous year.

The Rothamsted and Woburn field experiments dealt with :—

(i) the response of sugar beet to nitrogenous, phosphatic and potassic fertilisers, in a rotation experiment planned to bring out the characteristic seasonal effects.

(ii) the effects of nitrogenous fertilisers, spacing, and the means of incorporating mineral fertilisers, all treatments in all combinations.

Potatoes.—Experiments were made to compare poultry manure and ammonium bicarbonate with sulphate of ammonia as sources of nitrogen.

The manurial experiments of the past ten years were discussed at one of the Rothamsted Conferences and the papers presented there have been published.

Grassland.—The experimental programme is based on the fact that the manuring of grassland alters not only the yield and composition of each of the individual species of plants but also the balance of competition between one plant and another and therefore changes the entire flora. Two groups of investigation have been made : with phosphatic fertilisers, which broadly speaking tend to give a more pronounced leguminous herbage ; and with nitrogenous fertilisers, which tend to make the grasses dominant.

The work on phosphatic fertilisers has been done under the aegis of the Basic Slag Committee of the Ministry of Agriculture. The key experiments have been made at Rothamsted and numerous experiments have been made at various centres in the country. The outstanding result is the general superiority of superphosphate and of high soluble slag over the low soluble slag and on non-acid soils over ground mineral phosphate. On an average the high soluble slag has been about three times as effective in supplying phosphate to the plant as the low soluble slag containing equal amounts of phosphate ; while the mineral phosphate has been on certain acid soils about as good as the high soluble slag and on non-acid soils about as poor as low soluble slag. This superiority of the soluble phosphates shows itself not only in increased yield and larger proportion of good fodder plants but also in the higher content of phosphorus in the herbage, whereby its feeding value per ton is almost certainly enhanced.

So far the experiments have not shown where the line is to be drawn between the high soluble and the low soluble slags. Hitherto this problem has been unimportant, because most samples on the market were either above 75 per cent. or below 30 per cent. solubility. Now, however, there seems the probability that slags of intermediate solubility will be offered for sale and the work is being extended to cover these.

Other fodder crops.

Fodder mixtures.—An investigation was made into the yield and composition of fodder mixtures containing different proportions of

oats and vetches, grown with and without nitrogenous manure. The data are not yet fully worked up.

Lucerne.—The search for improved strains of bacteria for inoculation still continues : this is dealt with later.

Clover.—Cultures of the nodule organism have been prepared which, in preliminary experiments made in association with the Welsh Plant Breeding Station, Aberystwyth, greatly improved the " take " of clover on newly sown upland grassland. Should any extensive resowing seem likely to occur, this work ought certainly to be expedited so that the large scale distribution problems will be solved in time to meet the farmers' needs.

Kale.—This is proving one of the most valuable fodder crops on the farm. Our numerous experiments have shown how to obtain easily and cheaply crops of 25 or more tons per acre on our poor heavy land. The crop stands up well to the cold weather of our winter and in mid January proved very useful for the folding of our sheep.

Chemistry is not yet far enough advanced to give a complete statement of the feeding value of these fodder crops and it will be necessary to use the animal as the means of testing. As a preliminary, feeding experiments of a new type are being made designed to eliminate the effect of variations in location of the stalls and to reduce the effect of individuality of the animal.

Mangolds.—A statistical examination of the yields of mangolds on Barnfield for the years 1876 to 1930 (42) shows that deterioration of yield has not been pronounced when farm yard manure or complete artificials including nitrate of soda are given, but it becomes more marked when either nitrogen or minerals (potash and phosphate) are omitted. Slow changes in yield other than deterioration are unimportant except on the dunged plots : annual variance is increased by nitrogenous manuring but decreased by potassic fertiliser and also by rape cake or dung. Variations in rainfall do not account for the variations in yield due to annual causes though rainfall in excess of the average is somewhat harmful when it comes in Spring (mid March to end of May) but beneficial when it comes in June and July.

Soil cultivation.—Experiments with sugar beet and kale showed no advantage, and in some instances a positive disadvantage, from additional cultivation beyond what was necessary for securing a seed bed with one horse hoeing for keeping down weeds. The thinning of kale reduced the crop. This result is of considerable practical importance and the experiment should be repeated on other soils.

The potato cultivation experiments showed no advantage of autumn ploughing prior to the spring cultivations.

In view of the changes brought about by mechanisation in the cultivation of wheat and other cereals a number of experiments

have been made on different methods of seed bed preparation, including shallow and deep ploughing and rotary cultivation, each in conjunction with spring harrowing, rolling and top dressing with sulphate of ammonia.

The experiments already mentioned on different treatments of the preceding ley are also important for mechanised farming : these include the effects of cutting the leys twice, or once followed by summer fallow, against bare fallow. Three kinds of leys are included : rye grass alone, clover alone, and rye grass plus clover.

The improvement of field plot technique.—Considerable advances have been made during the year in the theory of field plot design, particularly as regards the " confounding " or combining of different problems into one experiment, the validity of the estimates of error, and the methods of analysis when the data are incomplete : as for example when one plot in a set of 144 is lost.

The working out of the experimental data has now become a formidable task, the number of plot yields analysed has risen from 328 in 1925 to 6,000 in 1932 and is still increasing.

(b) *Laboratory investigations.*

Field experiments necessarily remain purely empirical and limited in value until sufficient is known about the soil to show how far the results obtained on one field are likely to be obtained on another. Laboratory investigations of the soil are therefore made both on the physical and on the chemical sides.

Physical properties.—Dr. Keen's well-known investigations of the soil-moisture relationships have formed the basis of much subsequent work, which showed that the old " equilibrium values " of soil-moisture content had no actual existence although certain characteristic moisture contents could be recognised. Some of these are now being studied using sensitive electrical methods : they correspond to some kind of combination with successive but uniform increments of moisture. The well known " sticky point " appears to be the seventh of these stages.

Kaolin appears to behave in a similar way, and as its chemical and physical composition are better known than those of clay, it has proved useful in the interpretation of the clay phenomena.

Water, however, is not the only liquid with which the clay in the soil enters into some sort of combination : it combines also with other liquids. This subject has been studied using the change in specific volume of the clay as a measure of the degree of combination. Only polar liquids interact with clay so far as can be ascertained and the extent of the interaction (i.e. the reduction in specific volume) is approximately proportional to :—

(i) the number of exchangeable ions the clay can hold in equilibrium with a buffer of pH 7 ;

(ii) the mean charge density on the surface of the ions;
(iii) some property of the clay expressed by the shape of the clay titration curve.

When the liquids dry off, the clay particles tend to cohere to form aggregates or crumbs. This occurs, however, only in polar liquids, and it is marked only when the clay has an appreciable base exchange capacity, when its particles are small, and the exchangeable cations and polar groups of the liquids are also small.

All these phenomena can be explained on the hypothesis that the exchangeable ions of the clay particles interact with the molecules of the liquid if these are polar, the interaction being the simple orientation of the dipoles by the electric charges on the ions and the clay. This hypothesis promises to be useful in furthering our knowledge of clay and it is being developed.

A new line of investigation, the interpretation of which is not yet in sight, has been opened up. The curves expressing the relation between calcium uptake by different clays from calcium salt solutions of different pH values vary according to the clay but the variation occurs only at pH values below about 9·8; above this the curves are all similar. Whether this is a specific property of the calcium ion, or whether other ions behave similarly, is not yet known. The results are, however, curious and almost certainly conceal some property of considerable importance.

The clay investigations are already throwing light on other problems besides those relating to the soil. A series of experiments parallel to those already made with clay are being made with dough, dealing especially with viscosity. A difficulty on the theoretical side, which has been solved, was how to modify the ordinary Maxwell equation expressing the relation between rate of change of strain to rate of change of stress so as to make it fit the facts in regard to clay and similar substances. The new results are now being used to study the stickiness of dough in association with the Research Institute of the Flour Millers Association. This particular property is much used by the baker in assessing the value of the dough; it is being estimated by means of a Katinsky balance. The rheogram measurements already described have been extended and for the first time the important elastic and plastic properties of dough have been expressed in absolute (c.g.s.) units, while standardised methods have been set up for preparing reproducable doughs from flour samples.

The effect of yeast on these various properties has been studied.

The important technical applications of these various results are worked out at the Flour Millers Association Laboratory. The work affords an excellent example of the way in which a scientific investigation properly done may widen out wholly unexpectedly and throw light on problems far removed from those originally in mind.

Chemical properties of the soil.—The work during the past year has been concerned chiefly with the plant nutrients in the soil. The changes in nitrate content of the soil have been followed out during the period of plant growth, as also have some of the transformations of the nitrogen and the carbon compounds : these measurements have brought out some new facts which, however, cannot as yet be fully explained. Neither tares nor mustard ploughed in at Woburn had any important effect in raising yields of wheat. It has been shown, however, that in pot experiments barley benefits from the nitrogen of the tares so long as it is sown immediately after the burying of the green crop, but it does not benefit from the nitrogen contained in the mustard. The effectiveness of the nitrogen speedily decays, however, and if the sowing is too long delayed the barley gains but little from the tares. This is not a drainage effect, for it happens whether the soils have been leached or not. At Rothamsted the nitrate stored up during a summer or autumn fallow suffered a similar " decay " : it fell to a low level during winter. Yet the wheat crops that followed did not suffer in the same way : the yields corresponded more closely with the levels of nitrate present in autumn, and varying with the treatment, than to the uniformly low levels of the early spring. Dr. Crowther suggests two possibilities both of which are being further studied : the nitrate may be washed into the subsoil and held there till it is taken up by the crop ; or it may be converted by microorganisms into an insoluble form which is later broken down and becomes available to the crop.

In acid soils and on grass land, nitrate formation does not proceed far and considerably more ammonia accumulates. Evidence is adduced that grass frequently or even normally obtains its nitrogen not from nitrate but from ammonia.

Soil analysis.—New methods are now being devised in the physical and chemical Departments for estimating soil properties important in soil fertility, and we have a growing collection of soils of known response to fertiliser on which they can be tested. An important survey of the soils of a large rubber estate in Malaya is now being made ; based on this survey is an extensive series of manurial trials. A comparison is being made of certain tropical and subtropical soils by some of these methods to see how far the relationships already found are likely to hold true generally.

Rare elements in plant nutrition.—As for human beings and animals so for plants there are certain food substances which must be supplied or normal growth does not take place. In one of the first investigations on this subject made at Rothamsted small quantities of manganese were shown to be advantageous to cereals. Investigations showed that small quantities of boron are needed, and from various parts of the world there have since come accounts of plant diseases associated with boron deficiency. The appearance of this deficiency is less rapid in spring and autumn than in

summer, but plants require boron whatever the season. Some of the effects of reduced hours of daylight superficially resemble those of boron deficiency, e.g., both may prevent flowering, but the characteristic effects are entirely distinct. One effect of the lack of boron is to reduce the uptake of nutrients, calcium being more affected in this respect than either nitrogen or potash.

Fertiliser from waste coal.—In recent years various humic substances have been prepared from waste coal for which fertiliser value might reasonably be expected. Careful tests of materials supplied by well known experts in coal chemistry have however failed to reveal anything of value to the farmer. Claims of better success have been put forward in Germany, but so far we have no evidence that these are justified.

Lucerne and the nodule organisms.—The demand for cultures of the nodule organism still continues satisfactorily and we are informed that enough were sold last year to treat seed for 4,200 acres.

Meantime the study of the relations between the nodule bacteria and the plant is continuing. It is found that the infection of the host legume increases very greatly at the time when the true leaves open. At that stage the root hairs exude something which apparently causes the nodule bacteria in the soil to multiply : they in turn excrete something which causes the root hairs to curl ; and at the bend thus made they enter. A gum which does not decompose when heated in the autoclave has now been isolated from the bacterial excretions : it causes the root hairs to curl and also to grow, so that it is either itself a growth-stimulating substance or it is associated with one. Its action, however, is neutralised by a small quantity of nitrate ; the root hairs remain straight so that the bacteria cannot enter, hence the well known effect of nitrate in reducing the number of nodules or inhibiting their formation. This neutralising effect, however, is overcome by addition of a little sugar, suggesting that the carbon/nitrogen ratio, known to be important in other aspects of microorganic life, is important here also.

General Microbiology.

Some years ago it was shown that the number of bacteria in the soil is not constant, but varies from day to day and even from hour to hour. Improved and more rapid methods of counting have now enabled this work to be extended, and it is shown that the fluctuations still take place even when the temperature and moisture content of the soil remain constant ; this confirms an older observation. The fluctuations of the total number revealed by the direct staining method are of the same kind as those of the special groups that grow on the culture medium used in the plate method ; this is being further examined.

In attempting to find out the effects of the various groups of microorganisms in the soil it is important to know the relation between their oxygen uptake and their carbon dioxide output. This is studied in the microbiology department. The results are unsuitable for brief summary, but an interesting point brought out is that in young cultures the respiratory quotent (CO_2/O_2) is greater than 1 while in older cultures it is less than 1. The rate of oxygen uptake per 1,000 million cells reaches a maximum value about 60 hours after inoculation, whereas the rate of carbon dioxide output per 1,000 million cells is at its maximum in the first 24 hours after inoculation, and falls off as the culture ages.

An interesting survey of the protozoan faunas in the tobacco soils of South Russia has been made. All the soil samples contained protozoa, even those taken at some depth below the surface, while the upper layers of the soil contained them in considerable numbers. There was, however, no relation between the protozoan fauna and the soil type. Variations in acidity have but little effect on the fauna, though the optimum pH value varies somewhat for the different species.

Perhaps the two most important actions of microorganisms in the soil are the breaking down of the nitrogen compounds with production of nitrate and sometimes loss of nitrogen; and the decomposition of the non-nitrogenous compounds to carbon dioxide and water, a change which either involves their complete disappearance or it leaves a residue of humus. Both have been studied in detail.

Both changes are much influenced by the ratio of carbon to nitrogen in the substances present. The amounts of nitrite and of nitrate formed are both less when the ratio is high than when it is low. The rate of decomposition of sugar is greater when the ratio is low, but the rate of decomposition of cellulose is less affected though it varies in the same way.

Something depends on the nature of the nitrogen compound. In the decomposition of straw, ammonia is taken up by the organisms rather than nitrate in the early stages of decomposition but not in the later stages: in the end both are equally utilised though with nitrate the loss of nitrogen is greater. In the decomposition of sugar there is no evidence of any preference for ammonia over nitrate. The loss in presence of ammonia was about 14 per cent. with a C/N ratio of 8, but was nil, or even replaced by a slight gain, when the ratio was 84. Evidence is given that the loss of gaseous nitrogen takes place within the cell of the microorganism and is not a simple decomposition of ammonium nitrite. There is also evidence that in presence of nitrate the loss is still greater, though no definite figures can be given as it was not possible in these experiments to allow for any nitrogen evolved as gas.

Fungal tissue is equally available to microorganisms as a source of nitrogen and it is as easily and as completely nitrified as ammonia: it left no resistant unnitrifiable residue.

In all these decompositions brought about by microorganisms there is also much resynthesis, the organisms building up their body tissues out of the decomposition products. The sticky part of the humic residue left in the decomposition of farmyard manure is supposed to have considerable physical effect in the soil; its formation has been studied in detail. It is most easily formed when the decomposition is begun by fungi and then carried further by bacteria: the optimum pH is about 9·5 or 10. Nitrate and fungal tissue are better sources of nitrogen than ammonia, and the action proceeds better when the mineral bases are sodium or potassium than when they are calcium or magnesium.

Purification of effluents.—These results are being applied with considerable success to the purification of effluents from sugar beet factories and from milk factories. In both cases organic matter has to be decomposed and in both cases microorganisms are far the cheapest agencies for doing the work. The conditions required are a ready supply of oxygen, suitable reaction and suitable carbon/nitrogen ratio. The requirements may vary at different stages in the decomposition: thus the decomposition of complex substances like proteins and fats proceeds most rapidly when the first stages are done under anærobic, and the later stages under ærobic conditions.

For sugar beet factory effluents appropriate conditions have been worked out and the results are embodied in a report issued by the Department of Scientific and Industrial Research, under whose ægis all this work has been done. For milk factory effluents the problem is proving more difficult because of the presence of fat: this is an old trouble long familiar to sewage experts called upon to deal with the soap in domestic sewage. In view of its importance a special investigation of the decomposition of fat has been started. Conditions have been found under which both the fat and the casein can be precipitated from the effluent, leaving a liquid that can be run over biological filters without fear of clogging them.

Plant Pathology.

The work on black arm of cotton, the bacterial disease caused by *B. Malvacearum*, has been brought to a close and a report has been published. Work on wart disease on potato and on "take-all" (*Ophiobolus graminis*, Sacc) in wheat has been continued. The wart disease investigation is widened so as to include a study of some of the new varieties under examination at Ormskirk. A rapid method is used for distinguishing immune from susceptible varieties. An intermediate group of potato varieties has been found which, although attacked by the disease organism, has the power of sloughing it off so that it causes no damage or loss to the crop.

The surveys of fungus diseases and insect attacks on the experimental plots are giving a mass of valuable observational data.

It has been possible to continue in full the investigations on virus diseases of plants. In spite of many attempts no method has yet been found of growing the virus outside the plant. The analysis of virus diseases has continued. A fourth "ring spot" disease of tobacco has been found, caused by a mixture of two separate viruses neither of which alone can produce it. The aucuba virus of tomato which has been studied in our laboratory for some time is now shown to be a mixture of two which act differently and apparently are to some extent mutually inhibitory.

A beginning has been made on the application to plant viruses of the serological methods so much used in animal pathology.

Entomology.

The chief investigations dealt with in this Department are as follows:—(i) the factors responsible for the variations in numbers of insect populations; (ii) the causes of their attraction to the plant that they attack; (iii) methods by which they can be kept in check.

In studying the variations in numbers of insects from time to time Dr. Williams has arranged some ingenious light traps to take samples of the night flying insect population. The catches for each separate hour of the night are kept distinct, and records are taken showing the meteorological conditions throughout the night, including continuous records of rainfall, temperature, pressure, wind direction and velocity, humidity, cloudiness, and degree of brightness—a moonlight record. Data are being amassed but it is too early to discuss them as yet.

The infestation of wheat by the two blossom midges *C. tritici* and *S. mosellana* was much less than last year (0·6 and 1·4 per cent. kernel attack respectively against 5 and 10·5 per cent. in 1932), probably because of the earlier emergence of the midges which prevent them ovipositing on the wheat.

The degree of parasitism of the gall midges ("button top" galls) on basket willows was also much reduced, being about 13 per cent. instead of 53 per cent. in 1932. The number of insects obtained from the plants, however, showed no marked change as compared with 1932.

A detailed study has been begun of phenomena of oviposition by this insect on different willow species. The purpose is to find why the insect chooses certain species on which to lay its eggs: why it avoids others, and whether the species preferred can be made distasteful. The phenomena of gall formation are also being studied. It appears that willows can be divided into three groups: those on which eggs are laid and galls formed; those on which eggs are laid but no galls formed; and those on which no eggs are laid.

A sawfly *Pteronides Melanaspis* behaves towards the different willow species in just the opposite way to the midge. This suggests that a chemical constituent of the leaf is concerned, and

it is repellent to the one insect but attractive to the other. This work is being closely followed up.

A nematode parasite of a grass thrips (*Aptinothrips rufus*) is being studied, and also an internal fungus disease of the same thrips; so far the fungus has not been identified.

Insecticides.

Much work has been carried out in connection with insecticidal plants. Those containing rotenone and the pyrethrins are most valuable because although highly poisonous to insects they are comparatively harmless to human beings and domestic animals. Curiously enough rotenone is highly poisonous to fishes also. There is an increasing demand for this substance which so far cannot be made synthetically on the large scale; it therefore has to be extracted from plants.

Pyrethrum (*Chrysanthemum cinerariaefolium*) is a valuable insecticide, its flowers containing two important active principles —the pyrethrins I and II. Experiments are made in collaboration with the Plant Pathological Department of the Ministry of Agriculture to ascertain the effect of soil, season, manuring and other cultural operations on the yield of pyrethrin per plant and per unit area. The plant is perennial in habit, but requires a period of dormancy otherwise it gives poor yields of flowers; generally speaking the climatic conditions of this country appear to suit it better than those of tropical countries. The possibility of obtaining by cross fertilisation new and more potent strains than the old ones is being examined.

Unfortunately the pyrethrum dusts quickly lose their efficacy when exposed to air and light. Methods have now been devised for partially overcoming this.

Two groups of tropical plants, *Derris* spp. and *Lonchocarpus* spp. contain rotenone as well as other insecticidal substances and are included in the investigations. Some of this work is done in association with the East Malling Research Station and with the Department of Agriculture of the Federated Malay States; it is clear that Malay can produce excellent samples.

The increasing demand for rotenone and similar insecticides and the fact that the British Empire can supply the necessary plant materials either from the tropical or the temperate regions makes it very desirable that this work should be developed much more intensively than is being done at present. A very valuable line of work is in progress and the results are being closely watched by insecticide makers at home and in the United States.

Bee Research.

The useful investigations carried out during the last 11 years on the technique of honey production are now bearing fruit and the services of Mr. Morland are increasingly in demand among

bee keepers. Considerably more work has been done this year on the factors determining the rate of accumulation of honey in the hive, as measured by continuous weighing, and on internal economy of the hive, studied by closely watching the activities of marked bees in a glass hive. New and interesting observations are being made which are giving much valuable information about honey production, swarming, and other subjects of great importance to bee keepers.

Hitherto no work has been done on bee diseases, but these are now to be included in the programme and a bacteriologist has been appointed to study foul brood.

Farm Husbandry.

With the completion of the farm equipment it has now become possible for the farm staff to take up a number of farm husbandry problems which previously had to be neglected. Last year a beginning was made with a comparison of electricity with oil as motive power about the farm buildings. A new tractor was placed at the disposal of the Station by the makers in order that a comparison might be made with one that has done five years' good work on the farm. This work is carried out in close association with the Institute for Research in Agricultural Engineering, Oxford, and in consultation with the Agricultural Economics Research Institute, Oxford, and with representatives of electrical appliance makers. Other investigations deal with problems in sheep husbandry, the effect of grazing on pastures, etc.

Titles of papers issued during the year.

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FERMENTATION DEPARTMENT.

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GENERAL MICROBIOLOGY DEPARTMENT.

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2. MACAULAY INSTITUTE FOR SOIL RESEARCH, ABERDEEN

Soil Surveys.

(i) *Eastern part of Kincardineshire.*—This study is based on the recent survey of the area by the Geological Survey and the information collected by the Survey on their field maps is being used in the differentiation of the parent materials of the soils. The area is fairly complicated geologically, the northern part being formed of a belt of schists and gneisses, and the southern of conglomerate, sandstone and andesite. Overlying these are boulder clays, sands and gravels, morainic drift and alluvial deposits. There are also areas of peat. Representative profiles on these parent materials are being studied, and it is anticipated that the results of the survey will be issued in a chapter on the Soils and Agriculture of the area in a Geological Survey Memoir.

(ii) *Durris, Aberdeenshire.*—A soil survey of the woodland on the Durris estate, near Aberdeen, has been carried out in conjunction with Dr. G. K. Fraser, of the Forestry Department, Aberdeen University. The parent materials of these soils are glacial drifts, derived mainly from granite and gneiss, with some small patches of more basic material. The soils are all of the podzolic type, many being gleyed (a term applied to grey bands or spots, associated with poor drainage). The gley type is not confined to hollows or flats, but is also to be found on quite steep slopes, where there is a considerable flow of water down the slope. An attempt is being made to correlate tree growth with the chemical and other properties of these soils.

(iii) *Teindland, Morayshire.*—The experimental forest of the Forestry Commission at Teindland has been surveyed, and a special

study of the soils on a profile basis is being made. The parent materials in this case are glacial drifts from Old Red Sandstone Conglomerate, and the soils again fall into the podzolic group. A feature of the soils at higher elevations is the presence of an extremely hard and compact iron pan which has given rise to surface water-logging. Attempts are now being made to get rid of this pan by ploughing and draining.

(iv) *Insch, Aberdeenshire.*—The work which was going on in this area last year has been continued. It extends over granite, olivine norite and slate.

(v) *Carnwath, Lanarkshire.*—Areas of waste land near Carnwath and East Kilbride have been surveyed in connection with the Lanarkshire County Council's investigations into the possibility of land reclamation to alleviate unemployment. The problems in connection with draining this land were also studied. Preliminary examinations were made of derelict land in Renfrewshire, Ayrshire, Wigtownshire and Dumfriesshire.

Geological Work.

The mineralogical study of the soils of the north-eastern area of Scotland has been continued. This work has been extended to the determination of the parent materials of the soils of the areas where survey work is being carried on. It has furnished information, which has been lacking in the past, on the mineral composition of the glacial drifts from which most of the soils of these areas are derived. These glacial drifts have been formed from a variety of rock types, and the determination of their mineral composition has provided information regarding the unweathered minerals present, and also minerals likely to furnish plant nutrients. A detailed study is being made of the mineral content of the soils and parent materials in Kincardineshire. Marked differences in the mineral content have been found in this area, where the geology of the parent materials is complicated, and it is hoped by this means to grade the soils.

Soil Fertility.

Pot culture work.—Determinations of available plant nutrients by the Mitscherlich method were again carried out on a range of soils from different geological formations in Scotland. In 1932 samples from uncultivated areas were studied, and in 1933 the samples were drawn from adjoining cultivated land. The results were used for comparison with data obtained from field trials, laboratory tests and mineralogical analysis.

Pot experiments were also conducted to compare superphosphate, basic slag, ground mineral phosphate and "Sulfurophosphate" when applied to a peat, a peaty mineral soil, and a mineral soil.

Field experiments.—Field experiments by the Mitscherlich method were carried out on 37 farms throughout the country, with a view to estimating the amounts of available nitrogen, phosphate and potash. The soils used in the pot tests were all included in the field trials. Whilst the work done up to the present is insufficient for purposes of exact correlation, there are indications that the pot tests give low results for available phosphoric acid. This field method has also been employed to obtain an estimate of the amount of nitrogen available for the oat crop after lea.

Laboratory tests.—Laboratory determinations are being made on representative samples of all the soils examined in the pot experiments and field trials. With the results of these experiments as a basis for comparison, it is hoped to interpret more satisfactorily than in the past the results of laboratory methods for manurial and lime requirements. From the work already done a set of methods has been adopted provisionally for advisory work.

Advisory work.—A considerable amount of advisory work amongst farmers has been carried out, especially in the north-east of Scotland. Several hundred soil samples have been examined by the laboratory methods referred to above, and reports issued on the " lime requirement ", " available " phosphoric acid and potash, and on the organic matter content.

Joint work with the North of Scotland College of Agriculture.—Experiments with different amounts of nitrogen, potash and phosphoric acid are being conducted at Craibstone, and 96 plots in a rotation experiment, and 20 in a lime and phosphate experiment have been sampled. The changes in the soil are being followed by laboratory methods, and the results are to be correlated with the yields obtained at Craibstone.

Forest nursery soils.—In conjunction with Dr. G. K. Fraser an examination is being made of the manurial contents of several nursery soils. It is intended to compare the conclusions drawn from soil analyses with those reached by Dr. Fraser on the actual growth of the nursery stock.

The Study of Peat Soils.

Macaulay Demonstration Farm, Lewis (3).—The experimental programme at the farm has had to be curtailed and no further land has been reclaimed on the farm. The areas previously brought under cultivation continue to improve, especially the pasture. Very satisfactory results have been obtained in the establishment of pasture on certain areas without cultivation. Shallow open drains were cut where necessary and the land treated with shell sand, top-dressed with farmyard manure or compost, and sown out with a grass seed mixture. Dressings of phosphate and potash in addition gave still better results, and it is evident that with suitable

treatment much of the very poor grazing land on peat in Lewis and elsewhere could be greatly improved.

Wild white clover cleanings have been found useful as a cheap source of clover on very poor land which would not justify the use of expensive seed mixtures. Experiments with a range of grasses and clovers in small plots have been continued, and promising results have been obtained with sweet clover.

The Farm's implements and tractors have been utilised by crofters in various parts of the island for the purpose of bringing additional land under cultivation.

Laboratory and survey work on peat.—Rapid methods for the determination of plant nutrients in peat are being tried, and compared with the methods in use on the Continent. Acidity determinations are of particular importance, and a modification of the Tovborg-Jensen method is being tested. With the help of these methods, advisory work on peat land is being undertaken (4, 5, 6, 7).

Preliminary survey work is being done in different parts of the country with a view to classifying the peat deposits and obtaining some information as to the effects of climate, topography, etc., on their development.

In connection with the investigation of the possibilities of land reclamation in Lanarkshire, several areas of peat have been surveyed, and reported upon as regards drainage and suitability. Since much of the derelict land under consideration is peat, or peaty, the information already obtained in Lewis is proving very useful.

In addition to chemical analysis, pollen analytical work as devised by Professor von Post is being carried out, and certain interglacial peat deposits are being studied.

Special Investigations.

Mechanical methods of draining (8).—Tests have been carried out on mechanical drainage by means of a drainage plough on a variety of soils, including peats, stony loams and clays, and methods of drawing tiles and wooden drains into mole drain tunnels have been examined. In connection with this work, Mr. Monie has continued his experiments with a soil auger designed to provide a rapid means of making a general texture map of areas to be drained.

The measurement of soil colours.—The work reported last year has been continued, and in co-operation with an artist a colour chart in which soil colours are arranged in seven main groups, is being prepared.

Pasture experiments, etc.—Further work has been carried out on hill pastures in Midlothian in conjunction with Mr. R. G. Heddle of the Edinburgh and East of Scotland College of Agriculture, and a paper dealing with this has been published (9). The investigation

was commenced by the late Dr. W. G. Smith, and deals with an area of typical hill land on the College Farm at Boghall.

The joint investigation with the Animal Diseases Research Association on "Pine" was continued, and the results have been published (10).

Further work has been done at Craigiebuckler on the effects of various chemical lawn treatments on the soil, and experiments in Ayrshire on sports grounds have been continued.

Soil organic matter.—An investigation is being made into the composition and distribution of organic matter in some typical soil profiles from the north-east of Scotland, including forest humus layers under spruce, fir, beech and birch. In this connection, a modified wet combustion method, details of which will be published later, has been used for the determination of carbon and nitrogen.

The changes in the organic matter which accompany the humification processes are being studied by methods of proximate analysis, and also the effect of the presence of mineral matter on the results obtained by these methods.

The lime status of certain soils, and detailed studies of two soil profiles in the north-east of Scotland.—The laboratory and field investigations on the acidity and lime status of five soils described in last year's report have been continued. The results obtained in these investigations during the past two years are about to be published, and two further experiments have been laid down, one on an olivine norite soil, and the other on a slate. In the work now going on, particular attention is being paid to the effect of lime on the subsoils, and further work is being done on the olivine norite soils, as the one already studied gave results which differed considerably from the others.

A very detailed study of two soil profiles at Craibstone, derived from granitic drift and typical of the large areas in the north-east of Scotland, has been published (11). One profile was on cultivated, and the other on uncultivated land.

Forest soils.—Work is being carried out on two soils at Craibstone and Durris, which are geologically and ecologically similar, in an attempt to ascertain the factors associated with differences in the growth of trees. Areas of bracken, heather, whin, and Deschampsia have been selected for measurements of exchange capacity, and content of nutrients, and the results will be compared with distribution of vegetation and growth of trees.

Craibstone Lysimeters (12).

As was pointed out in the report submitted for the year 1931, unexpected results were obtained from the lysimeters bearing third-year grass treated under the system of manuring intensively with sulphate of ammonia after a dressing of phosphatic and potassic

manures had been given. Under the conditions of this experiment, when sulphate of ammonia was applied in quantities such as are ordinarily given in the intensive manuring of grassland, there was practically no loss of the nitrogen in the drainage. The yields of dry matter did not appear to support the claims sometimes made in respect of this intensive manuring.

In order to ascertain whether these results would be confirmed in a second season of intensive treatment, the grass on the lysimeters was dressed in 1932 in a similar manner. Lysimeter No. 1 was as usual unmanured, while Nos. 2 and 3 received a total application of 4 cwt. of sulphate of ammonia per acre. The first dressing, 1½ cwt. per acre, was given in March, and further dressings were given in June and August. The crop was cut at frequent intervals, weighed, the amount of clover in each cutting determined, and analyses made. The composition of the drainage and the amount of nitrogen contained in it were also determined.

The results obtained for the year 1932 confirmed those obtained in the previous year. The increase of crop due to the intensive treatment was confined to the grasses. The clovers were seriously diminished, and the diminution was much greater in the second season than in the first. In 1932 less than 1 per cent. of the dry matter produced on No. 3 was clover.

During the year 1933, the lysimeters have been cropped with potatoes (Kerr's Pink) planted early in April, 1½ cwt. sulphate of ammonia per acre being applied to Nos. 2 and 3 in May, No. 1 being as usual unmanured. This is the first time the lysimeters have been under potatoes. The crop was lifted in October, weighed, and analyses made. The composition of the drainage waters was determined monthly.

Titles of papers issued during the year.

1. Ogg, W. G.: The Macaulay Institute for Soil Research. *Aberdeen U. Review*, July, 1933.
2. Ogg, W. G., and Macleod, A.: Reclamation and cultivation of peat land in Lewis. IV. *Scott. J. Agric.*, **16**, 2, 1933.
3. Robertson, I. M.: Peat mosses. I. Their development and early utilisation in Scotland. *Ibid.*, **16**, 1, 1933.
4. ————: Peat mosses. II. The draining of peat land. *Ibid.*, **16**, 2, 1933.
5. ————: Peat mosses. III. Composition of peat and the liming and manuring of peat soils. *Ibid.*, **16**, 3, 1933.
6. ————: Peat mosses. IV. Cultivation and cropping of peat land. *Ibid.*, **16**, 4, 1933.
7. Monie, M. M.: Mechanical drainage of Scottish soils. *Ibid.*, **16**, 4, 1933.
8. Heddle, R. G., and Ogg, W. G.: Experiments in the improvement of hill pasture. *Ibid.*, **16**, 4, 1933.
9. Greig, J. R. (in collaboration with W. Godden, H. Dryerre, A. Crichton, and W. G. Ogg): Pine: A disease affecting sheep and young cattle. *Vet. J.*, **89**, 99, 1933.
10. Stewart, A. B.: The genesis and development of two profiles of a drift soil in North-east Scotland. *J. Agric. Sci.*, **23**, 73, 1933.
11. Hendrick, J.: Lysimeter studies at Aberdeen: *Mezögazdasági Kutatások (Budapest)*. 'Sigmond Special Number, **6**, 12, Dec., 1933.
12. Ogg, W. G.: Developments in soil science and recent British contributions to its literature. *Scott. Geog. Mag.*, **49**, 37, 1933.

3. CHEMICAL (AND ANIMAL NUTRITION) DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND

Soils and Fertilizers.

Bogland reclamation.—This work, mentioned in last year's report, has been continued. A paper (1) has been published showing the results of manurial and liming experiments carried out over a period of three years. The effects of farmyard manure and lime in combination with artificial fertilizers are described. An account is also given of the methods employed in cultivation and drainage and the approximate costs. In addition to crop yields the effect of the various treatments on the decomposition and acidity of the reclaimed peat has been studied.

The establishment of various grasses and clovers has also been investigated in small field plots.

Methods for determination of manurial requirements.—Further work on the Mitscherlich method for manurial requirement has been done. The manurial requirements of 22 soils have been determined by this method and in the case of 10 of these manurial trials have also been carried out in the field. It is hoped in this way to obtain information which will help in the interpretation of results of Mitscherlich tests and also the results of chemical analysis.

Lime requirement and soil acidity.—Many field experiments have now been started on various types of soils throughout the country. Data are being collected on the effect of lime on crop yields throughout a rotation.

Determinations of soil pH lime requirement, exchangeable bases, etc., are being done on soil samples taken before and after liming in order to study the effect of lime on the soil itself.

Mineral analyses of the herbage on the plots have been determined where practicable.

Advisory work.—During the year a certain amount of advisory work has been carried out in connection with liming, manuring and investigations of crop failures.

Title of paper issued during the year.

1. Baird, J. C., and Rae, R.: The reclamation of bogland and the production of seed potatoes. *J. Min. Agric. for N. Ireland*, **4**, 25, 1933.

4. RESEARCH INSTITUTE OF PLANT PHYSIOLOGY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Effects of mineral deficiency on barley.—An elaborate study of the interactions of nitrogen and potassium has been completed. The two manurial elements were presented in 25 different combinations, and their effects on the morphological development studied in detail. By chemical analysis the rates of uptake were calculated, and the following facts emerge. When in minimum the rate of uptake of each element is strictly proportional to the external concentration. The uptake of the element in excess shows a relative fall in rate of uptake with rise of concentration in the external solution. The concentration of the element in excess is always higher within the plant; hence elements in excess are used inefficiently in yield production (luxus consumption). Under conditions of correct physiological balance the yield curve is a straight line, showing a strict proportion between yield and manure applied. In every other case the yield curve is of the Mitscherlich type showing a diminishing return in yield as the manurial dose is increased.

Growth analysis has confirmed previous findings, that under conditions of nitrogen starvation leaf growth rate is greatly reduced but carbon-assimilation rate is unaffected, while under potassium starvation leaf growth rate is much less affected but carbon assimilation is greatly reduced. Leaf growth rate is thus shown to be largely independent of carbon assimilation. The respiration rates of the successive leaves borne on the main stems of plants from these cultures was studied. The increase in respiration with decreasing potassium supply was again obtained, and a large reduction with nitrogen deficiency. The effect has been analysed in terms of the metabolic changes due to manurial deficiency. Potassium shortage results in a low sugar content and a high amino acid content, nitrogen shortage leads to high sugar contents and low amino acid contents. Respiration is found to show a high positive correlation with amino acid content and with sugar content. With advancing potassium deficiency the respiration first rises with increase in amino acid, reaches an optimum and then falls away to limitation by falling sugar content. Nitrogen deficiency leads to low protein content so that respiration is low in spite of increased sugar content, presumably as a result of the small protoplasmic content of the plants.

A similar study of the interaction of phosphorus and potassium is in progress. Low phosphorus content leads to a low rate of respiration, in spite of the high content of reducing sugars as already established. The rate of respiration of such phosphorus-deficient leaves has been raised to the normal by feeding with a solution of inorganic phosphates.

An apparatus has been constructed for the study of the rate of assimilation of barley leaves in the field and attached to the plant, and also under conditions of normal CO_2 supply and normal daylight. The successive leaves on the main stem grown with three levels (1 : 9 : 81) of nitrogen supply have been studied. Very high rates of assimilation were obtained and it has been shown that nitrogen manuring has no effect on the assimilation rate, in spite of the large differences in structure and chlorophyll contents of the leaves. The findings based on growth analysis have thus been experimentally confirmed.

The effect of manurial deficiency and the water content has been further studied. A complex interaction of the effects of potassium, phosphorus and calcium has been established. A study has been made of the relation of manurial deficiency to respiration of mangold leaves using material from the Barnfield experiment at Rothamsted. The relation between respiration of leaves maintained for long periods in the dark to the change in sugar content is being studied in plants grown at three different levels of nitrogen.

After-effect of temperature on winter cereals.—This investigation has been carried a stage further. It has been shown that in discussing the failure or success of flowering two aspects must be clearly separated. The inception of flowering in winter rye depends on the germination in the sense that low temperature of germination hastens the differentiation of flower primordia and high temperature of germination, delays this stage. Day-length is concerned, as under short day conditions winter rye germinated at high temperature shows an acceleration in flower differentiation as compared with plants grown under long days, whereas low temperature germinated plants show a marked delay in flower differentiation under short day. Indeed, under short day conditions, the temperature of germination after-effect is completely masked, and so long as the plants are kept in short days they fail to reach the stage of " shooting." Removed to long days " shooting " begins at once in the low temperature germinated plants, and in consequence of the more rapid differentiation of flower primordia under the previous short day conditions, ears larger than normal are obtained. The plants germinated at high temperatures and then exposed for some time to short days also eventually " shoot " and produce ears, whereas if kept all the time in long days similar plants fail to flower. Temperature of germination has thus converted " long-day plants " into " short-day plants." The investigation is being continued.

Permeability of cells to water.—A study is in progress on the rate of uptake of water by whole plants under controlled conditions of water content, suction pressure and stomatal aperture.

Effects of alternating periods of light and darkness.—To test the effect of alternating light on the growth of the whole plant experiments have been carried out on cucumber plants grown in artificial

light under conditions of constant temperature and humidity. Alternating light and dark periods of one minute each lead to a great reduction in leaf growth, in dry weight increase and in assimilation rate, in comparison with plants receiving the same amount of light in periods of 12 hours light and 12 hours darkness.

Stomatal control.—The relation of stomatal aperture to the rate of transpiration and the water content of leaves is being studied by new methods. Two new types of porometer have been developed, one measuring the resistance to flow of air through the stomata, the other measuring directly the resistance to diffusion of gases. By a self recording modification of the first type the relation of stomatal movement to varying periods of alternation of light and darkness is being studied. It is found that with alternating light of approximately half-minute periods the stomata rapidly close. This effect diminishes as the period is either increased or decreased.

Electroculture.—The pot culture experiments of 1932 differ from those of previous years in showing no evidence of an increase of grain yield as a result of electrification, nor has the discharge had the usual effect of reducing the percentage of sterile flowers in the ears. This must be ascribed to unfavourable meteorological conditions during the year, for although the manurial and electrical treatment was the same as in previous years the yields in 1932 were much lower. In the years 1930, 1931 and 1932 the control plants showed a dry weight per pot of 871·3, 566·7 and 407·0 gm. respectively while the corresponding grain yields were 374·7, 218·9 and 121·3 gm. Similarly the percentage sterility was 25·0, 29·9 and 55·9 for the three years. The conditions during May were particularly unfavourable, the rainfall being high and the hours of sunshine low (2).

Physiology of tomatoes under glass.—This investigation, which is in progress at the Cheshunt Research Station, has been continued. A preliminary paper has been published (3) describing the methods by which the leaf area, water content, assimilation rate, translocation rate and respiration may be studied in young plants grown under normal conditions. The rate of increase of leaf area is shown to fall off with increasing light intensity and there is evidence of a supra-optimal light intensity at a total of 6,000 foot-candle hours during a period of 7 hours.

Chemical studies on the physiology of apples.—By the use of the " half apple " method a parallel study has been made of the chemical losses of sugar and acid on the one hand and of carbon dioxide losses on the other. It has been shown that while in Worcester Pearmain there seems fair agreement between " chemical " loss and " respiratory " loss, in Bramley's seedling the loss of sugar is much greater than can be accounted for by loss of carbon dioxide.

Titles of papers issued during the year.

1. Ashby, E.: Studies in the inheritance of physiological characters. II. Further experiments upon the basis of hybrid vigour and upon the inheritance of efficiency index and respiration rate in maize. *Ann. Bot.*, **46**, 1007-1032, 1932.
2. Blackman, V. H.: Fifteenth Inter. Rep. Electro-culture Committee. Min. Agric., 1933.
3. Bolas, B. D., and Melville, R.: The influence of environment on the growth and metabolism of the tomato plant. I. Methods, technique and preliminary results. *Ann. Bot.*, **47**, 673-688, 1933.
4. Gregory, F. G.: A simple device for regulating gas flow. *Ibid.*, **47**, 427-428, 1933.
5. Sen, P. K., and Blackman, V. H.: On the conditions leading to the injection of leaves submerged in water. *Ibid.*, **47**, 663-671, 1933.

B

PLANT BREEDING, CROP VARIETIES AND SEEDS

5. PLANT BREEDING INSTITUTE, CAMBRIDGE UNIVERSITY

Wheat.—The new varieties under test show, as is to be expected, comparatively small differences in their yielding capacity. They have been selected on the basis that nothing inferior in this respect to the standard (Swedish Iron) should be retained. The final selections are being made, therefore, on other characteristics of which, for the moment, standing capacity is the most important. A distinct improvement in this respect is now obvious and the original ideal of a stiff straw, some two feet nine inches in height, has been attained and the types possessing it thoroughly tested out under extreme conditions of intensive manuring. This shortening of the straw has occasionally been criticised by visitors to the Institute's plots, who in spite of the extraordinary frequency of old straw stacks throughout the country, question whether the new breeds will produce enough for their requirements. On the other hand, those interested in mechanised wheat growing show a preference for some of the still shorter types which, so far, have only been retained for use in genetic experiments.

The quality of the grain of these new types ranges from that of Square Head's Master to that of the excellent, though little-known, White Fife. In some cases it has been determined by means of baking tests, in others the supply of grain for this purpose is still inadequate and the quality determinations have been based on various gluten tests. The results of these over the past three seasons have been very inconstant. The extremes, whether strong or weak, occupy season by season much the same position in the lists, but the intermediate types of one season may be classed with the strong types of another. The 1932-1933 baking trials on wheats derived from the cross Yeoman × Chinese brought to light a type of loaf not hitherto met with in the course of the investigations on strength. The loaves had a perfectly smooth crust of a lively orange brown colour. The volume was satisfactory, but little significance can be attached to the figures for it, as the stock of flour was too small to permit preliminary experiments to determine the best conditions for baking.

In the crops harvested in 1933 the difference in appearance between wheats known to be either strong or weak is particularly

clear. As a result the grading of a number of F_2 generations, which it had been intended to grow on in the mass, was carried through in time for sowing in the autumn of 1933.

The investigations on cereal rusts were extended in various directions. More especially investigations were planned to throw light on the nature of rust resistance and on the factors responsible for rust epidemics. For this purpose the collection of some fifty rust resistant wheats was sown in addition to several large F_2 generations of crosses between resistant and susceptible varieties. The season proved to be an unfortunate one for work in the open field, for though trapping methods disclosed the fact that at times rust spores were abundant in the atmosphere, they failed signally to induce an appreciable outbreak of the disease. The only heavy attack of the common yellow rust occurred on a very susceptible variety, which is always planted in small patches as an infector throughout the crops. The usual methods for securing infection, such as cutting back the plants at flowering time and dressing with sulphate of ammonia, were ineffective and towards the end of the season rust cultures had to be started up for work under glass house conditions in the autumn.

Some progress was made with the investigation on the inheritance of the number of fertile flowers per spikelet, and though some points still have to be cleared up, it has become clear that this is a character to which the wheat breeder can usefully pay attention.

Observations have also been made on the inheritance of awns in pentaploid hybrids, in which several unexpected features have occurred. The usual examination of newly collected forms was continued and selections were sent to Cyprus and Australia for trial.

Statistical yield trials were made for the second successive year on selections of Rivett wheat. Two out of an original 200 single plant selections have now been handed over to the National Institute of Agricultural Botany for trial against commercial varieties.

A very large series of statistical trials of 25 new hybrid wheats, all now at the F_8 stage, was carried through. The parents involved are Little Joss, Yeoman, Wilhelmina, Iron and Browick. Originally there were over 5,000 separate F_3 families. These trials will be repeated in full again next year and the best three or four wheats will then be handed over to the National Institute of Agricultural Botany.

Trials of resistance to the wet-cold complex of winter were continued for a fourth year. They have shown no wheat to be more resistant than Wilhelmina, but they have also conclusively shown that to test for this form of resistance by simple growings in the open air, even on the wettest soil, is a very uncritical, unsatisfactory method.

A wide range of hybrids, aimed at obtaining shorter and better straw, continued to be investigated. The wide crosses, e.g., with *T. sphaerococcum* and other very short-strawed wheats, have not yielded results of promise as yet.

Oats.—The attempts to obtain a winter oat with better straw have centred largely round segregates obtained from the hybrid Argentine × Grey Winter. Of these, two in particular (Nos. 109 and 136), have received sustained attention, the former by reason of its high quality, good straw and a grain-yielding potentiality which is significantly superior to Grey Winter, and the latter on account of its high grain-yielding potentiality combined with remarkably good standing straw. Both appear to possess a degree of winter-hardiness in advance of that of the Argentine parent, but whilst 109 most nearly approaches Grey Winter, neither hybrid is equal to that parent in this respect. No. 136 is also distinctly inferior to Grey Winter in quality of grain.

As in several important respects No. 136 is a promising variety, an effort to circumvent the two attributes in which it is notably deficient was commenced in 1929, when it was back-crossed with the parent Grey Winter. Various selections from the cross reached the fourth generation in 1933, and from the best of these products single plant selections have been made for further study. It is not possible yet to form an estimate of the winter-hardiness of the new hybrids; many of them, however, exhibit a grain quality in advance of that of No. 136 and also possess remarkably good straw.

This year a further series of hybrids has been started by crossing No. 109 and No. 136; in this case there is a possibility of obtaining increased winter-hardiness by a combination of the somewhat limited degrees of this attribute present in the parents concurrently with better grain quality than that of No. 136. The colour of the grain will not complicate the problem, as both parents are white.

The "Ex 109/1" series was advanced a stage further and three selections were included in the routine quantitative yield tests. The oats of this series have maintained the early promise of good straw and grain, and high degree of winter-hardiness, and only their quantitative values now await determination.

The various cultures obtained from the hybrid Avoine d'hiver × Argentine reached the F_3 stage in 1933. The outstanding features of the segregates of this hybrid are large grain and good standing straw; but up to the present no form approaching No. 109 (Argentine × Grey Winter) in grain quality has been found. This hybrid is most promising and in the course of time should furnish some valuable material.

As will be noted from the above, the number of winter-hardy parents used for crossings is severely restricted, and an attempt

has been made to amplify the possibilities in this direction by introducing oats of a similar nature to Grey Winter and Avoine d'hiver from Russia. A series of these was cultivated as pure lines in 1933 and their value as parents will be the subject of investigation in 1934 and subsequent years.

The possibility of utilizing the Grey Spot resistance of certain Scandinavian varieties such as Mesdag and Fyris is under investigation, for which purpose crosses of those varieties with others particularly susceptible to Grey Spot were made in 1932. From the hybridized grains, F_1 plants were raised in 1933 and will be studied in the succeeding generation next year.

Barley.—An attempt to reselect Spratt-Archer 37/6 was commenced in 1930, when a large number of single ears exhibiting desirable features were picked out of a standing crop of that variety. These were grown as separate units in 1931 and the produce increased in quantity in 1932. In both these years a more intensive selection was made, using as additional desiderata good standing straw and low total nitrogen content in the grain. By these means the original number of selections has been reduced to 21, of which 5 were subjected to a quantitative yield test in 1933.

The observations and various determinations made up to the present justify a hope that improvements in quality, standing power and quality of the grain may be obtained shortly.

The possibility of obtaining still better yielding forms of barley is being explored and a series of back-crosses of Spratt-Archer with Spratt and with Archer, Archer-Goldthorpe with Spratt-Archer, etc. was made in 1931. These are now in the F_2 stage and very little information as to their possible value can be available for another year at least. In point of quality it may be said, however, that they exhibit a most promising range of material.

Out of the seven crosses originally made with the object of selecting malting barleys superior to those already in cultivation, two were discarded entirely after the 1932 harvest. From the remaining five crosses, thirty-three cultures were selected for further trial in 1933. Selection was done by eye judgment of malting quality coupled with notes of the quality in previous years. Of the cultures retained, some have shown quality which when judged by eye appeared to be superior to Spratt-Archer under the growing conditions at Cambridge. There are others which have shown distinct promise of good quality, but which have not been consistent from year to year. Finally, there are those cultures which have been selected because of good standing ability, or promise of good yielding ability.

It was decided to combine observations for another year with a yield trial. Accordingly the thirty-three cultures were split up into six groups of five, and one of three. Each group was put into a trial with either Spratt-Archer or Plumage-Archer as the standard, the lay-out being in the form of a Latin square.

The trials were very satisfactory as far as growing conditions were concerned. Excellent germination and plant survival were followed up by good growing conditions, though the dry, hot weather during the latter part of July and the beginning of August accelerated ripening rather more than was desirable for the production of good malting samples. The plots were cut before they were dead ripe in order to guard against loss of grain and ears.

Statistical analysis has shown that none of the cultures yielded significantly lower than Spratt-Archer, and one yielded significantly higher. In most cases the differences were too small in comparison with the error of the experiment. It is at present proposed to select five or six of the outstanding cultures and run them in a final trial in 1934.

A new series of crosses was also made in 1933. Three continental barleys, which are reputed to be exceptionally winter-hardy and strong-strawed, were crossed with the best of the malting barleys now being grown in this country. One of these continental barleys has lived up to its reputation as far as straw characters are concerned, and it also promises to be a high yielding strain by reason of its large ears and grain.

Crosses were also made between some American six-row barleys with exceptionally strong straw, and a series of English malting barleys.

It is hoped that these crosses will yield strains which combine some of these desirable characters, particularly those of malting quality and winter hardiness. This is desirable in view of the increasing practice of sowing malting barley in the autumn, a practice which is accompanied by no little risk if the winter happens to be severe. It is also proposed to select any strains which show promise of high yielding propensities in view of the increasing desirability of farmers producing more home-grown feeding barley.

Field Peas.—As a result of the yield trials in 1932, nine hybrid cultures were sent to the National Institute of Agricultural Botany for further trial. Of these, six were Maple types, all of them yielding significantly higher than the controls in the trials. Some of the cultures also showed desirable seed characters such as good shape, freedom from denting, and bright seed-coat colour. The other three cultures were of the Dun type, though they differed very much in seed size, shape and pigmentation. Each had yielded significantly higher than the control in the yield trials.

In 1931, twelve crosses were made between the best Duns and Maples and the well-known *Pisum sativum* forms Unica and Glory. Unica and Glory are early, short-haulmed, unpigmented forms, and it was hoped to transfer some of those characters to the Duns and Maples. Examination of the seed of F_1 plants in 1932 resulted in the rejection of four of these crosses temporarily.

The remaining eight hybrids produced eighty-one plants bearing over six thousand seeds. This number of seeds is too large for a manageable F_2 generation, but as seedling losses are high in peas, it was decided to sow most of the seed and thin out the plants.

From the F_2 generation interesting genetic data have been collected on time of flowering and its linkage with such characters as flower colour and haulm length. The seed coat data will require further investigation.

The final examination and selection of cultures for growing in 1934 has not yet been made, but the basis of selection will be on flowering data, seed shape and size, and seed coat colour. In addition, haulm length will be taken into consideration, but it is now doubtful whether this character has the economic significance it was thought to have had a few years ago.

Several new crosses were made in 1933 between the best Maples and also between the best Duns and between a particularly early new Maple from Tibet and the best of the Maple cultures.

Brassicae.—An extensive series of crosses between different species was made with considerably more success than was expected. Further as an aid to producing new forms in this genus the vegetative production of tetraploids is being attempted and preliminary observations were made with the object of acquiring the best technique for developing buds on wound callus.

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6. WELSH PLANT BREEDING STATION, ABERYSTWYTH

Oats.

White winter oats.—Weather conditions during the 1932-33 winter were not sufficiently severe to enable final conclusions on hardiness to be drawn with regard to the four new segregate strains of white winter oats included in this season's yield trial. Some amount of winter-killing was observed which indicated that the very stiff-strawed strain 1276 Cn 11 probably possesses a resistance to the prevailing winter conditions almost equal to that of Grey Winter, while the other three strains, namely, 3/103, 5/64 and 4/11, are slightly less hardy but superior to Bountiful in this respect. Yields generally were low owing to the shallow soil on which the trial was carried out, and 5/64 yielded slightly less than the check variety Grey Winter this season. The others were about equal or slightly superior to check.

A pure line strain of 3/103 (Marvellous × Grey Winter), namely S.147, has been handed over to the National Institute of Agricultural Botany, Cambridge, this autumn. This strain possesses grain of good size and quality.

Sister strains of 1276 Cn 11 possessing rather larger grain are being developed to displace this strain. The two other strains are being reselected before proceeding with further yield comparisons.

Spring Oats.

(i) *For good land.*—In the plot trials this season all four strains of the Victory-Algerian cross exceeded the check variety Record in yield. Two other strains, one from Golden Rain × Red Algerian and one a medium late selection from the cross Record × Radnorshire Sprig also gave superior yields. As a result of this trial the 15 strains may now be reduced to 4.

(ii) *For medium land.*—In the plot trials in this series 8 of 14 strains tested in yield plots in the previous year were included and to these was added one strain which did well in the 1932 rod-row trials, making a total of 9 strains for the 1933 plot trials. The check variety Radnorshire Sprig was the only variety to show any degree of lodging and that only to a slight degree. Of the 9 strains, 4 were outstanding in appearance in the field, and the weight data for grain and straw of these show them to be in every way superior to check. Three of these have white grain and the other black and all 4 ripen at about the same time as Radnorshire Sprig. These 4 strains which derive from the cross Record × Radnorshire Sprig have been selected for further yield testing in 1934.

New material derived from crosses between Victory and Black Bell III, Radnorshire Sprig × Black Bell III, Castleton × Black Tartar, Black Tartar × Record, and Golden Rain and Cornellian × Ceirch-du-bach, is now reaching the true breeding stage and a number of head selections and head-row progenies will come under observation next year. In view of the success attendant upon the researches at this Station connected with the improvement of poor grassland, the importance of varieties adapted to medium and poor land conditions is progressively increasing. The investigation of this group of material is, therefore, being looked forward to with a not inconsiderable degree of interest.

(iii) *For poor upland soils.*—In this section three strains, namely, 1/13, 5/205 and 11/160 of the cross *A.brevis* × *A.strigosa*, continue to show considerable promise. They have been included, amongst others, in a plot trial at Frongoch. The threshing of this trial has not been completed and yield figures for this season are, therefore, not yet available. The 3 strains mentioned were grown on a drill strip basis at two upland farms where they all did well. Next season it is proposed to conduct critical yield trials at one or more hill centres, in order to decide which of these three strains should be selected for multiplication with a view to marketing in the near future.

A large number of new head selections from later hybridisations of *A.brevis* with *A.strigosa* were made this season, while several

untested strains derived from the first cross are still under observation. Many of the latter show marked improvement upon the commercial Ceirch Llwyd in respect of the appearance and quality of the grain, but further investigation is needed into the relative feeding quality of the straw.

Seedling establishment.—In conjunction with the Advisory Mycologist observations and experiments concerned with the effects of seed disinfection were continued. Somewhat divergent reactions have been obtained which call for further experimentation in 1934. This year's observations seem to indicate that seed and soil, and possibly climate, have important influences upon the consistency of any beneficial reaction due to seed treatment.

Genetics.—The study of certain segregate types of the cross *A.brevis* × *A.barbata* has been continued. A large number of F_2 plants has been grown this year, and harvested for a detailed examination of the grain in the laboratory.

The pentaploid hybrids obtained in 1932 were grown and all failed to set seed on selfing. A limited attempt to produce seed by back-crossing did not meet with any better success.

A study has been made of the natural crossing in oats (1).

Cereal Synonyms.—The work of co-operation in connection with the identification of oat synonyms was continued, and 27 type varieties or their synonyms were systematically studied.

Herbage Plants : Breeding.

Grasses.

Perennial rye-grass.—The work on this species has been continued on the same general lines as in previous years. Several thousand single plants have been studied. These can roughly be classified in two main groups :—

(i) "*Original*" *plants.*—These are all derived from seed other than that produced at the Station. They have consisted in the present year mainly of lots of seed received from Australia and New Zealand, together with British commercial and co-called British indigenous. Two main objects are in view in these studies : (*a*) The discovery of single plants of outstanding merit for further study with a view to their use as basic plants in the establishment of new and improved strains ; (*b*) To obtain a general impression of the general type of plant produced by seed of different sources of origin. In certain cases, reports on the behaviour of the lots under Aberystwyth conditions are supplied to the senders of seed, although this cannot possibly be undertaken for all samples that are submitted.

(ii) "*Station-bred*" *plants.*—These are plants which have been produced as the result of selection and breeding at the Station. They again must be regarded as two somewhat

distinct subgroups: (*a*) Plants which are directly descended from provisionally selected "original" plants either in the first or later generations. They are mainly used as a means of studying the parent plants concerned, but also to some extent for the study of the effect of close breeding upon a population; (*b*) Plants representing new and old Station strains in various stages of development. They provide a test of uniformity of general type and also, roughly, of the degree of contamination that has occurred in the multiplication of the older strains. At the same time, they provide an opportunity for reselection work within the strains.

It was shown in last year's report what general progress has been made in the production of new strains, but it is possible that an explanation is required for the small number of new strains of this important species that is being developed.

Reference was made a year ago to the fact that the satisfactory isolation of small lots of basic material is much more difficult in perennial rye-grass than in some other species. Isolation by distance has been found to be entirely unsatisfactory where the lots are small and where, therefore, several generations must elapse before the seed of the strain becomes a commercial commodity. It had been hoped that greenhouse isolations would give completely satisfactory results, but experience has shown that this species is far less adaptable to this method than, say, cocksfoot and timothy.

A small greenhouse of a new type was erected in the gardens during the present year, and it would seem that decidedly better results may be expected from this new type, although a single season's experience is obviously insufficient to yield absolute conclusions.

Timothy.—The general lines of work with this species are very similar to those described above for perennial rye-grass. In the present case, however, less benefit is likely to be gained from the study of material from other countries. The material for the selection of potential parent plants is, therefore, much more limited and more difficult to obtain, and it is proposed that in the near future visits should be paid to certain localities for the collection of further material—either as rootings or as seed.

In the course of the year, Mr. Querashi completed his study of rust resistance in this species as far as this was possible within the time at his disposal. He confirmed that at least in the strain Bd 352 rust-resistance acts as a dominant character, and that at least in most cases the results approximately agree with expectation on a monohybrid basis. Some indication was found, however, that the inheritance of the character is not always of this simple type.

Such results are useful for selection and breeding purposes, but the fact that rust-resistance is a dominant character makes the work of effective selection for absence of rust disease difficult and

tedious, since each selected plant has to be tested by means of its progeny.

Red fescue.—Favourable reports on the behaviour of the old strain based upon B1 728 continue to be received, both from experiment centres in this country and abroad.

The work of re-selection in this strain has been continued, while other types are being sought.

Phalaris species.—The hybrid derivatives of *Phalaris arundinacea* and *Ph.tuberosa* are still being studied, and in the course of the year samples of seed have been sent to one institution in Germany and to two institutions in Australia. The seed sent does not represent the strains which are relatively true breeding, but samples from which a considerable variety of types may be expected have advisedly been sent, since such material gives a wider field for selection under conditions which may be different from those at Aberystwyth. At the same time, four relatively true breeding groups are being isolated for seed production purposes. These differ considerably from one another and have been selected mainly on growth type rather than on performance. While differing from one another, they also differ in their various ways from the parent species, *Ph.arundinacea* and *Ph.tuberosa.*

Genetical.—The most interesting event of the year was the publication of a paper entitled " The Cytology of Certain Intergeneric Hybrids between *Festuca* and *Lolium* " (3). This has carried forward the work on wide crosses very appreciably.

Breeding work has again received attention during the past season, but the results are not, as yet, available. Unfortunately, it has not been found possible to follow up the cytological work and much material remains to be examined by such methods.

The mode of inheritance of certain characters in perennial ryegrass has again been studied, but owing to technical and other difficulties progress is necessarily slow.

Legumes.

Red clover.—During the past season a number of the most promising families were further inbred, and about 80 crosses involving new selections were effected. Some of the best results last summer were given by crosses of late and early flowering types. In view of the excellent performance of these families several new crosses were made between the best inbred Montgomery and English broad red lines—the object being to produce a comparatively persistent strain with a longer growing season than Montgomery red clover. Several crosses were also made between Montgomery and English lates with the object of increasing the persistency of the latter.

Some 5,000 single plants of 10 different stocks of English late were planted with the object of carrying out a more intensive

breeding programme with English late. Seed from 16 new strains, 6 earlies, 6 lates, 3 wilds × lates and 1 wild, bred in 1931, were harvested for inclusion in field tests next year; and 6 new strains, 3 lates, 2 wilds × lates and 1 wild, bred in 1932, were sown for multiplication. Two more strains were produced during the season; one was built up from 22 unrelated families and the other from 10 families.

White clover.—The usual routine work concerned in the selection, crossing, and testing (4) of white clover was continued. Several new highly productive families were isolated from the 1931 crosses. These will constitute the nucleus of a new strain which will be formed in 1934. The 5 new strains produced in 1931 were harvested and will be included in strain trials next year. Another new strain which, it is hoped, may prove valuable for hill pastures is being multiplied for seed.

Lucerne.—So far only one new strain of lucerne has been produced, and this is now being multiplied for seed.

The Station is co-operating with various centres in different parts of the Empire and on the Continent in conducting an " International Trial " with different geographical types of lucerne from Central Asia, together with a few European varieties.

Kidney Vetch.—About 2,000 single plants from 8 different European countries were planted with a view to selecting improved pure lines of this crop.

Birdsfoot trefoil, crimson clover and M.lupulina.—Work on these crops is being continued.

Genetics.—Considerable progress has been made in the study of the genetics of red clover (5) and a great deal of information is now available concerning the mode of inheritance of many of the outstanding characters of this crop. Investigations on the genetics of various " economic " characters such as earliness, hardiness, growth habit, mildew resistance, and of botanical characters such as hairiness, flower and seed colour, anthocyanin, chlorophyll deficiencies and dwarfness, are being pursued.

Grassland Agronomy.

Important aspects of the work have been reported in connection with (*a*) the work of the Grassland Adviser (see p. 331) and (*b*) investigations on the improved management of grassland (see p. 333). Some further particulars of the investigation as a whole may be given here.

Trials with sheep.—These experiments are being continued and extended. The results from one series of experiments where tethered sheep have been used have been reported upon, while

a further report (6) has been issued dealing with the effect of varying the periods of rest on the live weight increase of sheep.

The trial involving 48 pairs of tethered sheep referred to in last year's report has been carried through a second year. The highest live weight increase has been obtained from plots sown with wild white clover and indigenous perennial rye-grass. All plots sown with wild white clover have given a higher increase in live weight of sheep than the corresponding plots in which wild white clover was omitted from the seeding.

Much time has been given to the collection of data from the numerous experiments concerned with the influence of differential schemes of grazing upon the botanical composition of the sward, and a report is in preparation.

Palatability and seeds mixture experiments.—The question of palatability continues to receive much attention, and a report (7) on extensive experiments has been published. Attention has been concentrated on the question of miscellaneous herbs and relative to the dry matter percentage of different strains and species of grasses and clovers compared to that of representative miscellaneous herbs.

The seeds mixture work has been concerned with the competitive influences between indigenous and non-indigenous strains, and is in support of the trials in the counties conducted by the Grassland Adviser.

General grassland experiments.—Experiments have been continued on the influence of nurse (8) and on the effects of different methods of grazing upon the establishment of seeds mixtures.

Critical trials are also in progress as to the precise influence of different manures on natural hill swards (9). The work on the inoculation of wild white clover has been continued, and an interesting report (10) has been published.

The Cahn Hill Improvement Scheme.—The work undertaken in connection with this Scheme is in a sense quite independent of that of the Welsh Plant Breeding Station as such. The Scheme is now in full working and possession has been taken of nearly 3,000 acres of hill land. The operations of improvement were begun at Lady Day, 1933, and already over 50 acres of hill land have been ploughed, and about 30 acres have been dealt with by various means of surface cultivation. The aim of the Scheme is not to conduct detailed researches but to manage the whole of the lands on a plan dictated by the results obtained from the hill improvement researches of the Station; and to convert as large an area as possible of the rough grazings into improved pastures.

Accurate costing accounts are being kept, and in this connection the Scheme is fortunate in having the co-operation of Professor Ashby and the Department of Agricultural Economics of the University College of Wales.

Seed Production and Isolation.

In the spring of 1933 further stocks of the seven pedigree strains of grasses released in 1932 were supplied to the seed trade. One pedigree strain of meadow fescue was, in addition, released for the first time.

Gross multiplication stocks of fourteen strains of grasses and clovers were made on nine farms in 1933. These farms were situated in two districts, one within a radius of ten miles from Welshpool, and the other within a radius of seven miles from Hereford. Thirty-seven acres were harvested in 1933, and a further acreage of sixteen acres were laid down on seven farms.

Initial multiplications of thirty-two strains were made in small islands on the Station farm and on farms in the neighbourhood of the Station during 1933.

The conditions for harvesting seed crops were exceptionally good during the summer of 1933, but the prolonged drought had an adverse influence on the size of seed, and caused some species of insect pests to be more numerous than usual.

The distribution of various insect pests affecting seed crops is receiving attention. Evidence suggests that midges affecting meadow foxtail seeds are much less prevalent at 900 ft. than at lower elevations.

Work is being continued on the influence of the time of sowing on the seed production of grass species. The indications are that for slow growing species such as red fescue and sheep's fescue autumn sowing is preferable. Where the soil contains inordinate quantities of annual weed seeds, autumn sowing may also be advantageous for other species.

Progress has been made in the understanding of the effect of fertilizers on seed production of grasses and clovers. Nitrogen stimulates seminal reproduction in most grass species. Red fescue is one of the exceptions: nitrogen has an adverse effect on its seed yield. Red clover under certain conditions responds very definitely to potassic fertilizers. Nitrogen, on the other hand, when used alone does not appear to stimulate increased yield of seed from red clover.

Lines of work are being extended to study various methods of growing grass and clover strains for seed on a farm scale. Measures to reduce the lodging tendency in rye-grass and red clover (11) are being investigated, and the effect of a nurse crop on successive seed crops of grasses is being followed up. Further use is being made of certain strains of rye-grass and red clover to study the efficiency of distance isolation for seed production.

Investigations are in progress to study the effect of various conditions of storing red clover seed on the viability of the seed over a number of years.

In view of the increasing demand for improved stocks of improved local varieties of oats a Seed Growers' Association has been formed in the district to function as a connecting link between the Station and the hill farmer.

Plant Physiology.

The work is being continued on the lines set down and the following points are of interest.

Seedlings of *Lolium italicum* have been found under certain conditions to inhibit completely the development of seedlings (younger than themselves) of *Festuca pratensis*, *Phleum pratense* and *Poa trivialis*. The latter are, however, extremely persistent and after remaining latent for several months are capable of normal growth under favourable conditions on the removal of competition with the older seedlings. Light and mineral nutrition are both factors in such competition. Owing to the seeds of *L. italicum* germinating more readily than those of the other species at low temperatures, differential germination may follow the sowing of a seeds mixture, and so bring about unequal competition. Latency in the seedlings of *F. pratensis*, *Ph. pratense* and *P. trivialis* might then result and could be followed by normal growth on any removal of the *L. italicum*. This is thought to be the explanation of the phenomenon of " delayed establishment " of grasses as it occurs in farming practice.

A distinction has been found between the ability of seeds of " commercial " and " indigenous " strains of grasses to germinate in solutions of cane-sugar. The behaviour of the seeds is, however, influenced by the conditions under which they have been grown and matured. This work is also being carried out with oats.

Attempts to stimulate the germination of *Dactylis glomerata* by treating the seeds with various chemicals, have been uniformly unsuccessful (12). Germination in this grass, is, however, considerably accelerated by soaking the seeds in water, and this beneficial effect is not destroyed by prolonged subsequent drying (13). This acceleration has been found to be due to the entrance of water into the seed being greatly facilitated by such treatment. In other species of grass the effect is much less pronounced, and in some cases does not occur. Pre-soaking causes an acceleration of germination also in oats, but it is brought about in a way quite different from that in the case of *D. glomerata*.

An investigation has been made into the seeds present in a viable condition in the soil underlying pastures. It has been found that these often show little relationship to the surface vegetation. The relative abundance of the seeds of different species varies enormously, the seeds of some plants (e.g. *Lolium perenne*, *Dactylis glomerata* and *Achillea Millefolium*) being almost completely absent. It would seem that most grasses depend on vegetative reproduction in maintaining their occupation of the ground;

possible exceptions to this are, however, *Holcus lanatus*, *Agrostis* spp. and *Poa* spp. In seeds which have been buried in the soil, germination occurs in some species after a prolonged period of dormancy.

The development of *Lolium perenne*, *Dactylis glomerata* and *Trifolium repens* in poor hill-soils at an altitude of 1,000 ft. has been studied in relation to manurial requirements.

Empire Grassland Investigations.

Mr. Davies returned to Aberystwyth at the end of December last from his extensive tour in Australia, and on the return journey he also re-visited New Zealand. Full reports concerning the three years spent in New Zealand and Australia are nearing completion, and a preliminary report of the tour in Australia has been published (14).

Since December Mr. Davies has been in this country. He has visited other research stations, and has been conducting investigations at Aberystwyth relative to a number of the problems his tours have brought to the fore.

A large number of samples of grasses and clovers in connection with seed production schemes in operation in New Zealand, and suggested in Australia, have been grown and kept under observation at the Station.

Titles of papers issued during the year.

1. Jones, E. T.: Natural crossing in oats. *Welsh J. Agric.*, **9**, 115-132, Jan., 1933.
2. Jenkin, T. J.: Interspecific and intergeneric hybrids in herbage grasses. Initial crosses. *J. Genet.*, **28**, 2, Dec., 1933.
3. Peto, F. H.: The cytology of certain intergeneric hybrids between *Festuca* and *Lolium*. *Ibid.*, **28**, 113-156, October, 1933.
4. Williams, R. D.: White clover trials, 1926-1930. *J. Min. Agric.*, **39**, 708-718, Nov., 1932.
5. Williams, R. D., and Silow, R. A.: Genetics of red clover (*Trifolium pratense* L.) Compatibility I. *J. Genet.*, **27**, 341-362, May, 1933.
6. Jones, Ll. Iorwerth: The effect of varying the period of rest in rotational grazing. *Welsh J. Agric.*, **9**, 159-170, Jan., 1933.
7. Stapledon, R. G., and Milton, W. E. J.: Yield, palatability and other studies on strains of various grass species. *Welsh P. Breed. Sta. Bull.*, Series H. **13**, 1-79, Oct., 1932.
8. Jones, T. Emlyn: The effect of a nurse crop on the establishment and first year yields of various grasses and clovers when sown in pure plots and in mixtures. *Welsh J. Agric.*, **9**, 176-190, Jan., 1933.
9. ————: Sulphate of ammonia compared with nitro chalk as a nitrogenous fertiliser on an open hill *Molinia* pasture. *Ibid.*, **9**, 191-195, Jan., 1933.
10. Poulter, A. A.: Deficiency of the clover nodule organism on some Welsh soils. *Ibid.*, **9**, 145-159, Jan., 1933.
11. Evans, Gwilym: Manuring of red clover for seed. *Ibid.*, **9**, 135-141, Jan., 1933.

12. Chippendale, H. G.: The effect of some chemicals on germination in cocksfoot (*Dactylis glomerata* L.). *Ann. Appl. Biol.*, **20**, 369-376, Aug., 1933.
13. ———: The effect of soaking in water on the "seeds" of *Dactylis glomerata* L. *Ann. Bot.*, **47**, 1-9, 1933.
14. Davies, W.: The grasslands of Australia and some of their problems. Council for Scientific and Industrial Research, Australia. Pamphlet No. 39, 1933.

7. SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING, EDINBURGH.

Cereals.

Oats.—The oat-breeding experiments were continued and many unfixed hybrids were grown for comparison and selection and for the purpose of obtaining genetical data.

In one series of crosses some relatively short-strawed plants have been selected through several generations with a view to procuring varieties with a high degree of resistance to lodging. Most of the selected short-strawed plants possess well-furnished panicles, and they appear to produce a good yield of grain. Differences are apparent amongst the selections in respect of grain type and several representative types which now seem to be breeding true have been chosen for further comparison.

With a view to obtaining improved early-ripening varieties a series of very early-ripening hybrids were examined, and a number of selection were made. Many of these early-ripening selections possess rather weak straw and give indications of producing rather low yields of grain. It is intended to make some back-crosses to see whether a capacity to produce more grain and a better type of straw can be combined with a capacity to mature at a relatively early period.

Further data were collected from two F_2 generations and one F_3 generation of oats with regard to the inheritance of striped leaves. The data obtained show that this character is transmitted through the female parent only.

Twenty-one fixed hybrid selections which have reached the field-trial stage and nine named varieties including Elder, Marvellous, Potato, Record, Sandy, Victory and Yielder were grown in randomised plots, and the data which were obtained for yield of grain were examined statistically. The results of this trial showed that a number of new hybrid varieties were of sufficient promise to be included in further trials. Several hybrid selections which did not come up to the required standard were discarded.

One of the selections from the progeny of a cross between Potato and Record was tried on an extended scale in 1933. Favourable reports from different districts have been received regarding this variety. It has been included in the registration trials of the

Department of Agriculture for Scotland, and it has been recommended for registration. About 15 tons of seed of this new variety, now known as Early Miller, were available for distribution early in 1934.

Wheat.—Several unfixed hybrid progenies were grown for comparison and selection. A number of types which seem to possess a high degree of winter-hardiness and also appear to be resistant to lodging have been selected for further comparison.

Barley.—The more promising varieties in the collection of hybrid barleys mentioned in the previous report were compared in small trial-plots. Two of the most promising of these have been retained for further trial. The others have been discarded as they did not possess the desired qualities.

Potatoes.

In 1933 over 2,500 seedlings were raised at the Sub-Station, Ainville, Kirknewton, and more than half of these were obtained from artificial hybridisations made for the purpose of procuring a range of early-ripening seedlings for comparison. Amongst the seedlings there was a high proportion of early-maturing types, many of which showed distinct promise.

The investigations on the effect of repeated self-fertilisation of potatoes were also continued, and over 900 plants were grown for observation. The majority of the selfed lines have now reached the sixth inbred generation and several are fairly uniform in type. A few hybridisations of distinct lines have been made.

Over 300 seedlings derived from wild solanum species and species hybrids were also grown for further observation and experiment.

The seedlings, numbering about 670, selected in previous years were grown in small trial plots for further comparison and selection. A collection of seedlings was also grown at other centres, and much information has been obtained concerning them. Several have been selected for inclusion in the Registration Trials, Department of Agriculture for Scotland, in 1934.

About 250 seedlings, raised at Ainville Sub-Station, were also tested at the Plant Breeding Station, Corstorphine, and their probable degree of utility ascertained by comparison with standard varieties. Several of the most promising were also grown in multiplication plots.

Seedlings were sent for inclusion in the single-tuber trials at Philpstoun, in the miscellaneous trials at East Craigs and in the laboratory wart disease tests, these trials and tests being conducted by the Department of Agriculture for Scotland.

A number of seedlings were also sent for inclusion in the preliminary trials carried out by the Ministry of Agriculture and Fisheries, at Ormskirk. In the wart disease immunity trials there, three varieties were included in the 1st-year test and two in the 2nd-year test.

A total of twelve varieties were included in the registration trials of the Department of Agriculture for Scotland, eight in the 1st-year test, three in the second and one in the third. The last mentioned seedling has given encouraging results, and it will be included in the Department's 4th-year test.

Much data have been collected concerning the inheritance of morphological and physiological characters of the potato. A paper (1) on the inheritance of tuber colour was published in 1933.

Herbage Plants.

Three new strains of pasture grasses were submitted for trial this year to the Field Trials Committee of the Department of Agriculture for Scotland. In addition, seed was supplied to a few farmers for test under pasture conditions on a larger field scale. During the year another pasture strain (diploid timothy) was multiplied in sufficient quantity to permit of its inclusion in a field trial next season. A third strain of timothy is now approaching the multiplication stage.

During the past year attention has again been concentrated on the breeding of pasture strains of timothy especially for those areas which at present support only a poor type of vegetation.

The breeding work has been divided into two parts (*a*) the raising of strains, and (*b*) the solution of fundamental problems relating to strains. The raising of cross-fertilising grass strains—units which are composed of a greater or lesser number of genetic types centring round different mean values—demands a different technique from that applicable to the self-fertilising cereals. In grass strains genetic purity is in many cases undesirable on account of self-sterility, and also because of the fact that pastures in general must persist through more than one year. It was therefore deemed necessary during the year to pay more attention than hitherto to certain important problems relating to the ecological races existing within species, and to the question of maintaining bred strains at a desired genetic equilibrium.

Much time was devoted during the summer to the study of population variability and type, and for this investigation the very suitable species, *Plantago maritima* was again employed in addition to various timothy races. There is some evidence to show that when environmental selection is reduced to a minimum population composed of interbreeding individuals can be maintained in relatively stable proportions. On the other hand, when a population, stable under one set of conditions, is exposed to the influence of environmental selection the type may be changed without any appreciable alteration in the percentage of variability. The study of wild populations has also made available certain data which may assist in the description and recognition of strains (2).

Swedes and Turnips.

The examination of methods of breeding of root crops and in particular the possibilities of producing true-breeding strains of swede by continued selection and by self-fertilisation under artificial isolation, was continued. Lines originating from commercial varieties were maintained and new additions made : but the segregating generations of artificial crosses provided the material from which most of the new selections were taken. Some of the longer established lines were crossed.

Further investigations were made on the manner of inheritance of various characters, such as yield, dry-matter percentage, colour of flesh and skin, type of foliage, disposition to bolt, malformation of bulb and resistance to finger-and-toe disease.

(i) *Leaf shape.*—Observations were as usual made on the small and somewhat vague variations in size and pattern of swede leaves, because of their effect on improving or marring the appearance of a strain, and because of probable difference in photosynthetic efficiency. During the period covered by this report a number of observations were made as to the inheritance of a major variation in leaf shape, a spatulate entire leaf form, resembling that of a primrose, which is found in certain varieties of garden swede. When a variety of this type was crossed with a variety having the normal pinnatifid leaf the F_1 hybrid was normal, except for a somewhat larger terminal lobe. The F_2 generation segregated approximately 12 normal : 3 semi-lobed : 1 entire. The semi-lobed type has a long terminal lamina, with numerous small lobes or leaflets at the base. It appears that no type of foliage of improved economic value is likely to appear in such a cross.

(ii) *Bulbless bolter.*—Rogues of swede crops collected from various sources, and believed to be rape, were compared with specimens of the commercial rape, provided by the New Zealand Department of Agriculture to illustrate a classification formulated by them. Most of the rogues are similar to Type II (rigid shaw), some to Type I (swede-like shaw) and one strain, previously unidentified, approaches Type III. From October, 1932, to January, 1933, certain lines were examined in replicated yield trials, wherein yield, bulbweight dry-matter content and in some cases soluble solids content were determined. Selection on the basis of dry-matter percentage and bulb weight was employed on populations of F_2 generations derived from parents of hard and soft types.

Pedigree lines were sown out in duplicate plots with suitable controls and observed throughout the season. Yield trials were prepared for the autumn. Notes were taken on Mildew disease and finger-and-toe disease and further observations were made on Swede × Turnip hybridisations.

Potatoes—Virus Disease Investigations.

Plant Breeding Station, Corstorphine.—The work on the carbohydrate metabolism of healthy and crinkle potatoes conducted at this station during 1932 has now been completed and published (5).

The investigation of the nitrogen metabolism of healthy and leaf-roll plants has also now been completed and published (6). Contrary to expectation, it was found that the nitrogen metabolism of diseased plants did not differ fundamentally from healthy, although the actual concentrations of the different nitrogenous products were in many cases lower in the diseased as compared with the healthy, e.g., protein.

The nitrogen metabolism of healthy and crinkle plants has been investigated during 1933. The results are not yet completed, but up to the present they reveal that there are marked and fundamental differences in crinkle nitrogen metabolism. As far as can be stated from the evidence at present available, the mosaic diseases (e.g., crinkle X,Y, etc.) do not appear to disturb the carbohydrate metabolism of the plant to any extensive degree, whereas in leaf-roll the reverse is the case. The nitrogen metabolism of plants suffering from those mosaic diseases is very considerably disturbed, and possibly loss in yield is to be correlated with disturbed nitrogen metabolism.

Genetical investigations have been continued and seedlings from last year's crosses were grown at Huntly.

North of Scotland Sub-Station at Gibston, Huntly, Aberdeenshire.—The inquiry into the effect on the progenies of parents affected with virus diseases has entailed a genetical study of the inheritance of certain " degenerate " characters. Data have been obtained which lead to the suggestion that the character previously referred to as " true degenerate " and possibly also that referred to as " wavy ", is inherited in Mendelian fashion and is dependent entirely upon the genetical constitution of the parents. The appearance of the degenerate character " seedling leaf-roll " in seedling progenies can be correlated with the presence of virus diseases in the parents. The number of seedlings of this type in progenies of similar parentage is variable but the data suggest that the number is dependent upon the type of virus with which the parents are affected and also upon the constitution of the parents. A large number of fertilisations were made during the year for the purpose of continuing this investigation.

Several progenies of selected parentage have been raised with the object of examining the problem of the inheritance of susceptibility to virus diseases. Laboratory methods of determining relative susceptibility are now under investigation.

Material has been obtained for a comparison of the carbohydrate and nitrogen metabolism of normal potato plants and plants affected

with the virus of simple mosaic (4). The data for the carbohydrate investigation are almost complete and will be shortly available. It is hoped to complete the nitrogen analyses next year.

Titles of papers issued during the year.

1. Black, W.: Studies on the inheritance of tuber colour in potatoes. *J. Genet.* **27**, No. 2, May, 1933.
2. Gregor, J. W.: The ecotype concept in relation to the registration of crop plants. *Ann. Appl. Biol.*, **20**, No. 2, May, 1933.
3. Robb, W.: Society's Annual Report for the year ended 31st March, 1933.
4. Cockerham, G.: Variations in the total nitrogen content of normal and leaf-roll potatoes. *Proc. Leeds Phil. Soc.*, **2**, 375-382, 1933.
5. Barton-Wright, E. C., and McBain, A.: Studies in the physiology of the virus diseases of the potato. II. A comparison of the carbohydrate metabolism of normal with that of crinkle potatoes; together with some observations on carbohydrate metabolism in a " carrier " variety. *Ann. Appl. Biol.*, **22**, 4, November, 1933.
6. ————: Studies in the Physiology of the virus diseases of the potato. III. A comparison of the nitrogen metabolism of normal with that of leaf-roll potatoes. *Ibid.*, **22**, 4, November, 1933.

8. PLANT BREEDING DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Oats.—The new oat variety, Stormont Arrow, appears to be well established in the favour of the farming community. The amount of seed the Division has available each season is quite insufficient for the demand for fresh supplies. In certain districts the variety is replacing Crown and King, hitherto regarded as the varieties likely to make most of good cultural conditions.

In the series of trials conducted in poor, and often hilly, cultural conditions the new strain selected from the cross Potato-Sandy has done fairly well but has not been outstanding. Much interest is, however, being shown in the variety as there is a general objection to Poland on account of its late-ripening habit, although this variety generally leads in actual test results.

A new selection of the local hill oat, Tyrone Tawny, has been eagerly welcomed, also in face of the probability that it will yield less well than the strain previously selected.

This preference is explained by the new selection's possession of a much shorter and plumper grain than the older type.

Flax.—A third season's test plot results confirm the findings of the two previous years. The new varieties Stormont Gossamer and Stormont Cirrus may now definitely be taken to represent an improvement in yield of scutched fibre per acre of crop of 50 per cent. and in crop value per statute acre, at the prices ruling during the test period, of over £7, an increase of 60 per cent. Stormont Gossamer took 1st prize for fibre flaxes in the World's Grain Exhibition at Regina.

9. NATIONAL INSTITUTE OF AGRICULTURAL BOTANY, CAMBRIDGE.

Crop Improvement Branch.

Yield and quality trials and observation plots.—In field trials in 1932-33 there were seventeen varieties of winter wheat, nine of winter oats, four of spring wheat, two of spring barley, ten of spring oats, seventeen of peas; ten strains of sugar beet, five of lucerne, and two each of Thousand Headed kale and Marrow Stemmed kale. Six of the winter wheats were tested under high farming conditions and four of these also under normal manuring. Thus the trials contained eighty different stocks of which twenty-nine represented new varieties or strains not yet on the market.

In observation plots there were over two hundred varieties of the principal farm crops. There were also small scale trials at Cambridge of eight varieties of wheat, of nine varieties of spring barley, and of twelve varieties of spring oats. In all, fifteen different crops are represented in plots.

The Institute has embarked on the first stage of a comprehensive programme of trials of mangolds and swedes. When sufficient evidence has been obtained as to the merits of any strain or strains of roots, the trade have undertaken, given sufficient time, to build up adequate stocks, to ensure that farmers will be able to procure authentic seed of the strain or strains in question without difficulty. Observation plots of mangolds were sown at all six stations and swedes at all except Good Easter (6, 7).

Another mild winter prevented the Institute from obtaining from its sub-stations conclusive evidence as to the resistance of autumn sown crops to frost. The precaution had, however, been taken of arranging for the new white winter oats (under numbers) to be grown in the open at the North of Scotland College of Agriculture, Marischal College, Aberdeen, and the State Institute for Plant-breeding, Wageningen, Holland, and in addition they were tested in refrigerators by Dr. Gassner, Institut für Landwirtschaftliche Botanik, Braunschweig, Germany, and at Svalöf in Sweden by the methods devised by Dr. Gassner. Although the results were not entirely in accord with one another, they afforded sufficient evidence to justify a decision to proceed with the multiplication for marketing in the autumn of 1934 of one reasonably hardy oat variety from the Cambridge Plant Breeding Institute, which had also acquitted itself well in the trials, and of one more hardy variety of promise from the Welsh Plant Breeding Station. The small available quantity of pure seed of the latter will not permit its being multiplied to a marketable bulk before the autumn of 1935.

With the increasing use of nitrogenous fertilisers in cereal growing, resistance to lodging has become a matter of prime importance. To test this feature satisfactorily it was felt necessary to adopt a new form of trial layout, and this was done for the first time

this season. Five varieties of stiff-strawed wheats were grown at each of the six stations in 1/30th acre plots. The plots were were laid out on the Latin square principle with five replications. The drilling and harvesting of these trials were done without difficulty and this form of trial promises very satisfactory results.

For the first time, too, arrangements were made for a number of new and old varieties of wheat, including both autumn and spring forms, to be sown at the six stations at three different sowing periods in spring. Although the programme could not be completely followed, the information obtained has been useful and the method will be followed still further.

Trials of Marrow Stemmed and Thousand Headed kale were begun at Cambridge.

A new programme for the testing of sugar beet strains was commenced in 1933. Six strains approved by the Factories were grown in a main trial at four stations. These strains were lifted about the end of September to discover which strain is most suitable for early lifting, and the trials will continue for three seasons. A supplementary trial was also begun at four stations which included five strains which the Institute thinks are promising on the grounds of their behaviour in observation plots.

Thirty-two strains were grown in observation plots at five stations. Of these, thirteen were grown from seed as supplied by factories to the growers in 1933, the object being to check for the factories the identity and quality of the commercial stocks supplied. Seed for the remaining plots was obtained direct from breeders. Altogether seven fresh strains of sugar beet were grown for the first time by the Institute, most of them at Cambridge only. Papers 5 and 16 describe the earlier results from sugar beet trials.

Dry, sunny weather continued throughout early autumn, and consequently the season provided no test of the standing capacity of any of the cereal varieties. The combined effect, however, was that harvest was one of the easiest and earliest within living memory.

Some of the more important points which emerged from the 1932-33 trials are :—

The new wheat from the Plant Breeding Institute, Cambridge, grown as 162/8/1E, has in the first year's trials revealed what appears to be a definite superiority over most others in yield combined with great powers of resistance to lodging.

The future of W. 70A and W. 70E remains as yet uncertain. Spring sowings at various dates indicate W. 70E as a possible variety for spring cultivation.

Of the spring oats under trial the variety Eagle has shown distinct promise of outyielding Victory.

The fourth year of the lucerne trials at Good Easter continues to show a slight superiority of Provence, though Hungarian is a close competitor. At Bridgham on blowing sand

in each of two seasons, English, Grimm and Hungarian have been definitely superior to Provence. Marlborough and Hunter River were poor.

The kale trials at Cambridge in 1933 have shown that in the case of the marrow stemmed type distinct differences exist between some strains in respect of yield and proportion of stem to leaf. In the strains of Thousand Headed kale tested such differences appear to be negligible, but a larger number of strains will have to be tested before this point can be established.

The Home Grown Wheat Committee of the National Association of British and Irish Millers continue to assist the Institute by determining the quality of the wheat grown by milling, analysing and baking the grain from the trials. The results obtained from the 1931 crop have been published (4).

Co-operation with other bodies.—The list of varieties undergoing trial affords ample evidence of the continuation of co-operation with the plant breeding stations at Cambridge and Aberystwyth; included also in the trials are productions from the Albert Agricultural College, Glasnevin, Dublin, and the Plant Breeding Division of the Department of Agriculture for Northern Ireland. Seed of cocksfoot has again been grown for the Scottish Society for Research in Plant Breeding. In its turn the Institute has been assisted by Armstrong College, Newcastle-upon-Tyne, which undertook on its behalf a winter oat trial at Cockle Park and a spring oat trial on a farm in Northumberland; the Hertfordshire Institute of Agriculture also carried out a winter oat trial. Further tests of the frost resistance of the new winter oats in which the Institute is interested are being carried out by the Institut für Landwirtschaftliche Botanik, Germany, and by the Instituut voor Plantenveredeling, Holland. The Agricultural Institute at Kirkton again came to the Institute's help in conducting trials of wheat and potatoes. Close touch continues to be maintained with the Cambridge Potato Virus Research Station.

The year has seen the development of much closer contact with the Sugar Beet Factories' Committees and their fieldsmen, and assistance has been given to the Selby factory to carry out sugar beet trials on similar lines to those employed by the Institute. In addition the Institute has continued its tests on the winter hardiness of autumn sown sugar beet for a Hungarian breeder, while the Cambridge Plant Breeding Institute has taken over from the N.I.A.B. four beets from these strains and has procured seed from them.

Co-operation has continued with Directors of Research Institutes and Agricultural Colleges and with County Agricultural Organisers in the conduct of spring oat trials. In spite of the decrease in the number of centres, valuable information has been forthcoming,

confirming in particular the merit of Golden Rain II throughout the country. In 1934 Victory and Marvellous will disappear from the trials, sufficient information having been obtained concerning their characteristics, and the trials will continue with Golden Rain II, Star, Eagle and Progress. The results obtained from these trials in 1931 have been published (3).

Seed growing.—During 1933 a stock of Spratt-Archer barley, originating from Dr. Hunter, was offered for sale through the seed trade and 55 quarters were disposed of. The same stock is again being multiplied for marketing for spring sowing in 1935. In addition a later selection of Spratt-Archer is being kept in readiness for multiplication should public demand and future field trial results indicate the desirability of this course. A stock of Yeoman II wheat is now in process of multiplication with a view to having available for sale 80 to 100 quarters in the autumn of 1934. Wilhelmina wheat is also being grown on for possible marketing at a later date.

Apart from the multiplication of the new white oat 136/17 mentioned elsewhere in this report, another white winter oat known as S.82 bred by the Welsh Plant Breeding Station is being grown on with a view to marketing it in 1935. Several new varieties and selections of winter and spring wheat are at present at an early stage of multiplication pending the outcome of the trials in which they are represented.

Seed for the county oat trials is again being grown and is regularly supplied at cost price to those participating.

Cereal synonyms.—Stocks of suspected synonyms were again grown at Cambridge, the Welsh Plant Breeding Station, the Seed Testing and Plant Registration Station for Scotland and also by Mr. T. E. Miln. The Cereal Synonym Committee met twice and at their second meeting again invited representatives of the firms concerned to visit the plots and discuss their own productions. A second report was issued to the constituent bodies and a summary was published (14). It is gratifying to be able to record that it was found possible to omit from the 1933 leaflet fourteen synonyms which had appeared in that for 1932 because they had disappeared from seedsmen's catalogues. A leaflet giving the finding of the Committee on the plots grown in 1933 has been issued (18).

Official Seed Testing Station.

The Station tested 30,499 samples in the twelve months ended 31st July, 1933. This is 190 fewer than in the previous year, which was a record. The number of samples received from outside sources was however 27,839, or 140 more than in 1931-32, which had been a record also in this respect. This is more than gratifying, showing as it does the continuation and indeed the increase in the confidence accorded by the public to the work of the Station. A noteworthy feature was the marked increase in the number of samples

of wheat submitted for test; this was obviously attributable to the renewed interest taken in this crop as a result of the establishment of the wheat quota. The number of samples tested for investigational purposes was 2,660. The investigations in question dealt mainly with lack of vitality in storage, but every year special problems arise which are too diverse to enumerate in this report. Study was continued of the impurities normally present in imported cereals of different origins. As an outcome of this work the Station has already been able to assist outside enquirers and is now in a position to form a very reliable opinion from laboratory examination alone as to the countries of origin of the great majority of samples of imported cereals which may come into its hands.

Much work has again been done on the relation between the germination of peas and of various Brassicas in the laboratory and greenhouse and that obtained in the field. The Station has been able to show in certain cases of failure of " plant " in the field that this was due to abnormal soil or climatic conditions and not to faulty germination.

The Wild White Clover Growing-On Committee met on 20th June, 1933, and examined the plots sown in 1932 together with a number of others upon which no definite recommendation could be made in 1932. The number of plots passed up till July 31st was 569, and the number sown was 821.

Potato Trials.

Yield and maturity trials.—Misfortune overtook the potato yield and maturity trials at Ormskirk during the season under review. A severe and prolonged gale struck south-west Lancashire on 31st July. It twisted and laid flat the foilage of the majority of the potato varieties, many of the haulms actually being broken off. Even where haulm damage could not be seen many of the leaves died off as though they had been affected by severe frost. Up to this point the growth of the potatoes on the field in which the yield trials and virus disease investigations were being carried out had left nothing to be desired. In the trial field in which the immunity and susceptibility trials were planted an attack of eelworm, accentuated by the extreme drought, had occurred in spite of the land having had two years' rest from potatoes. The effect of the storm was such that all the trials save one, the first early Arran Pilot v. Ninetyfold, had to be abandoned.

The Lord Derby Gold Medal trials shared the fate of the remainder, and the producers of the three new varieties which had been entered have been invited to submit them for re-trial in 1934 free of charge. An account of the 1931 Gold Medal trials has been issued (8).

Quality trials.—In spite of the destruction of most of the plots planted to provide material for further investigations on canning quality, it was possible to send samples of tubers of ten varieties

to Mr. F. Hirst of the Campden Hill Research Station for this purpose, and a sample of Ally was supplied to Professor C. K. Tinkler of King's College, London, for continuing his investigations on a laboratory method of testing for blackening.

The official immunity trials at Ormskirk.—Drought prevailed throughout the season with only a temporary break in October. In consequence, although the wart disease immunity trials were situated in the most highly infected field at the Station, wart did not make its appearance even in the control plots of Up-to-Date or among other known susceptible varieties until the end of July. Thus no decisions on the field susceptibility of any of the first earlies could be reached. At the end of August, however, entries other than early varieties which had shown susceptibility in the laboratory also showed it quite freely in the field. It also appeared abundantly on Up-to-Date, mainly round the base of the stem, but many tubers were also found to be affected on lifting. There were 48 entries for the first year trial, of which three were of the early type, and 20 for the second. 20 came from the official stations of Northern Ireland and Scotland under the scheme of interdepartmental checking. There were 39 control and key plots, making 107 in all. Leaving out of account the three the immunity of which could not be determined, all but five of the remaining 85 new varieties were free from wart in the field. In addition there were 138 entries for the susceptibility trials of which 54 were tested by the indoor method, the remainder arriving too late for a laboratory test. This entailed the indoor testing of 532 tubers, of which only 8, or 1·5 per cent., rotted in the process. 44 specimens from the contact tests were sent to Miss Glynne at Rothamsted Experimental Station for examination.

Potato synonyms (9, 10, 13, 17).—In spite of the effects of drought and eelworm infestation, the Potato Synonym Committee was able to make decisions in the vast majority of cases, and it is gratifying that among the entries for the first and second years' immunity trials only 2 (or 3·1 per cent.) were adjudged to be synonyms. This is the lowest ratio yet obtained, and the Committee have expressed the view that even these could be ascribed to lack of knowledge. On the other hand, in spite of the publicity given to the matter, all the firms who had been found to be selling potato synonyms in 1932 were continuing to do so in 1933. In addition, stocks from three other firms (making 12 firms in all) proved to be synonyms. Twenty-two synonyms were advertised for sale by seedsmen—in the great majority of cases at enhanced prices.

Other activities.—An investigation was started to test a method of laboratory determination of the health of " seed " tubers by the amount of discoloration produced by the insertion of a strip of copper into them. This method was discovered by Mr. H.

Bechhold, of the Institut für Kolloidforschung, in Germany, and so far the results at Ormskirk show distinct promise.

The virus disease trials and those designed again to test the effect on a small topped variety of growing it in proximity to a more robust variety met the same fate as the majority of the other trials, and the work will have to be repeated.

The usual collection of the principal established varieties, together with the recently listed immunes, was again grown and was of great value to the Horticultural Inspectors of the Ministry of Agriculture during their usual annual course of instruction at the Potato Testing Station.

Titles of papers issued during the year.

1. Thirteenth Annual Report.
2. Parker, W. H.: The methods employed in variety trials by the National Institute of Agricultural Botany. *J., N.I.A.B.*, **3**, 2, 137, 1932.
3. ————: County spring oat trials, 1931. *Ibid.*, **3**, 2, 142, 1932.
4. Humphries, Sir Albert, Humphries, S., and Read, L. H.: The quality for breadmaking purposes of wheats harvested in 1931. *Ibid.*, **3**, 2, 147, 1932.
5. Armstrong, S. F.: Sugar beet variety trials, 1931 (with Appendix by Parker, W. H.). *Ibid.*, **3**, 2, 150, 1932.
6. Parker, W. H.: Mangold variety trials, 1929-31. *Ibid.*, **3**, 2, 164, 1932.
7. ————: Swede variety trials, 1929-31. *Ibid.*, **3**, 2, 182, 1932.
8. Parker, W. H., and Bryan, H.: Lord Derby Gold medal potato trials, 1931. *Ibid.*, **3**, 2, 189, 1932.
9. Salaman, R. N.: Report of the Potato Synonym Committee, 1931. *Ibid.*, **3**, 2, 193, 1932.
10. ————: Report of the Potato Synonym Committee, 1932. *Ibid.*, **3**, 2, 198, 1932.
11. Eastham, A.: Thirteenth Annual Report of the O.S.T.S. for England and Wales, 1929-30. *Ibid.*, **3**, 2, 202, 1932.
12. Humphries, Sir Albert: The practical value of the work of the Institute. *Ibid.*, **3**, 2, 218, 1932.
13. Varieties of potatoes with their synonyms, immune from and susceptible to wart disease. (Revised edition 1933.)
14. Summary report of Cereal Synonym Committee, 1933. N.F.U. Rec., **22**, October, 1933.

FARMERS LEAFLETS.

15. No. 2. Varieties of cereals for spring sowing. (Revised edition January, 1933.)
16. No. 5. Strains of sugar beet. (Revised edition January, 1933.)
17. Potato synonyms.
18. Cereal synonyms.

10. PLANT REGISTRATION STATION, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

Potatoes.

Laboratory tests for immunity from wart disease.—In the routine of applying intensive tests of infectivity by wart disease to new varieties of the potato by the method of contact inoculation, the technique has been perfected to a point where almost every variety reacts. Of 180 varieties tested in sample of four tubers or over, only two failed to exhibit the disease in any stage.

Two varieties, on which in laboratory test the parasite completed its life history with the accompaniment of the production of rugose warty tissue, failed to give indications of susceptibility under field conditions.

Registration scheme.—Fifty-four varieties were submitted to test with a view to subsequent registration. Six of these proved susceptible to wart disease. Five were identical with standard varieties. Of the remainder, 15 were recommended by the Synonym Committee for extended test in 1934. Of the 17 varieties in their second year of test, six were recommended for further trial. Of the three varieties in their third year of test, two were recommended for an extended trial in 1934. No variety was recommended for registration.

Scheme for building up healthy stocks of potato varieties.—Work under this scheme has been continued. The following figures show the progress made during the year.

Excluding King Edward and Great Scot which were not included in the building up scheme the total acreage of stock seed in Scotland in 1933 was 381½. Of this amount 123⅗ acres were built-up stocks or their derivatives. The built-up stock seed includes 62¼ acres Majestic, 18¼ acres Golden Wonder, 12¼ acres Kerr's Pink, 5½ acres Catriona and 4 acres Up-to-Date. By this scheme stock seed of certain established varieties such as Catriona, Witchhill and May Queen was made available for the first time, while the built-up stocks of Majestic, Champion, Arran Chief and Duke of York were markedly superior to the stock seed of these varieties when last available a few years ago.

The acreage of built-up stocks which qualified for the special stock seed certificate was 19⅗ acres. The total of special stock seen was 25⅝ acres of which 5½ acres were comprised of new varieties.

It is estimated that the extent of built-up stock bulked for the first time in the spring of 1933 and not entered for inspection was eight acres and that the built-up stocks to be bulked for the first time in the spring of 1934 will amount to 12 acres. In addition, the produce of 56 one-cwt. lots isolated in turnips in 1933 should

plant about 14 acres in 1934. The number of growers of one-cwt. lots was 33.

The total number of built-up stocks in the possession of the original growers is 68, comprising 17 varieties. The numbers of built-up stocks distributed to other growers are not included in the above figure.

There were also 79 stocks in various stages of propagation in 1933.

The total number of growers engaged in the scheme is 105 and the total number of stocks is 147 plus 64 one-cwt. lots involving 25 varieties.

Virus diseases investigations.—Investigations under greenhouse conditions are being continued for the study of problems arising out of the following work which is carried out by the Department :—(i) Field inspection of potato crops for health; (ii) Building up healthy stocks of potatoes; and (iii) Testing of new varieties in respect of resistence to virus diseases. The material for the investigations has been obtained partly from potato crops during the course of inspections and partly from the potato virus research centres at Dublin and Cambridge. In the past five years several hundred stem grafts and needle inoculations have been made.

The following notes indicate the compass of the investigations :—(*a*) Evidence has been obtained (i) that Dr. K. M. Smith's Y virus occurs frequently in Scottish stocks of Majestic, Great Scot, Up-to-Date and Sharpe's Express (ii) that the secondary symptoms of Y vary considerably even on one variety. (*b*) It has been confirmed that Professor P. A. Murphy's simple mosaic is identical with Smith's X virus. (*c*) Various types of diffuse mottling have been found to be due to simple mosaic. (*d*) The mottle symptoms of simple mosaic have a wide range of expression even in one variety. (*e*) It has been confirmed that apparently healthy Irish Chieftain carries Murphy's virus A and that the latter virus allied with simple mosaic produces Murphy's crinkle. (*f*) Evidence has been collected that much of the severe mosaic in Scotland is due to virus Y rather than to Murphy's crinkle. As Y is readily insect borne (as opposed to the X constituent of crinkle) the spread of severe mosaic in Scotland can thus be explained. (*g*) Types of streak have been investigated including streaks carried by Up-to-Date and Di Vernon. (*h*) In some varieties streak symptoms are believed to occur which are not the result of virus infection, which are not perpetuated by the seed tubers and which seldom appreciably diminish the crop yield. (*i*) Advantage has been taken of D. Atanasoff's report on sprout grafting to carry out a large number of tests by his method which has the advantage of permitting a large number of tests to be completed in the field before insects are about. It has been found to be much more reliable than core grafting. (*j*) Investigations with plants which show mosaic symptoms on single stems only have been carried out and the proportion

of the progeny likely to be affected has been ascertained. (*k*) The total disappearance of a virus from units at one time visibly affected under controlled conditions, has been recorded in a number of instances. (*l*) Experiments on insect transmission were commenced in large cages each capable of holding nine large plants. The cages are made of fine gauze muslin on a wooden framework and are considered to suit potato plants better than small cellophane cages. (*m*) The tests for the quantitative resistance of new varieties to leaf roll and mosaic diseases are now confined to field trials located in sheltered conditions where such diseases are likely to be readily transmitted. Results to date of five years' tests show that only leaf roll has been transmitted but it is intended next year to utilise as mosaic infectors plants known to be afflicted with Smith's Y virus which is aphis borne.

Skin Spot.—Investigations on the effect of the application of dry dusts and wet treatments to infected stocks immediately after their being lifted and the mode of entry of the fungus are being carried out.

Oats.

One variety only (No. 644) submitted by the Scottish Society for Research in Plant Breeding was continued in test in 1933. This variety was recommended for registration as an early stiff-strawed variety of excellent grain-yielding and straw-yielding capacity.

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11. CROP (AND ANIMAL HUSBANDRY) DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Grassland.—The grazing experiment, commenced in 1929, has been continued. The plots were manured in the spring of 1932 as indicated in the last report and no additional manures were applied until the spring of 1933 when plots 1, 4 and 5 each received a further dressing of 1 cwt. of sulphate of ammonia.

In the third grazing year very little difference was found in the stock carrying capacity of the five plots, but a marked preference for plots 4 and 5 was shown by the stock, especially the dairy cows. These plots were ploughed up and sown down with seeds, mainly indigenous strains, at the beginning of the experiment and during the season they appeared to be fresher and looked much greener than the other three plots. Unfortunately the water supply for the field was inadequate during the prolonged dry weather and the stock had to be removed. This factor interfered with the grazing during the summer.

Reclamation of bog.—The work in the reclamation of used-up bog has been completed and the results published (1). Thirty-one acres have been reclaimed over a period of three years and this land has proved very suitable for the growing of " seed " potatoes. It is interesting to note that the cost of reclamation during the above period was recouped from the sale of the " seed " potatoes.

Manurial experiments have been carried out on the reclaimed bog-land, the results of which have shown the importance of applying lime and farmyard manure.

Drainage.—Further drainage work has been carried out at the Research Institute Farm.

The trench cutting machine referred to in the last report is very efficient as an excavator and was in constant use during the winter and spring of 1932-33, when a further 50 acres were drained. The labour costs were very materially reduced by the use of the machine and it is proposed to drain another field in the near future.

Crop drying.—Further trials have been carried out at the Research Institute with the crop drying machine which was installed in 1932. The first trial was carried out during very warm dry weather early in July, 1933. The grass, from a hay field, was cut in the morning, allowed to lie all day, and was turned over the following morning and immediately carted to the drying machine.

The second trial was carried out with grass which was cut and passed through the drying machine on the same day.

Better results, as would be expected, were obtained from the first trial, as the moisture content of the grass before drying was considerably less than that of the grass in the second trial. While the efficiency of the machine for drying is satisfactory, the output is not sufficiently high to warrant commendation, and further trials will have to be carried out before any definite conclusions can be formed.

Cost accounts.—The keeping of cost accounts has been continued on the farm of the Agricultural Research Institute of Northern Ireland, five years' accounts being thus completed. The accounts have been of general use, as previously, and have been of particular use in providing costs of the erection of the pig plant at the Institute.

Paper issued during the year.

1. Baird, J. C., and Rae, R.: The reclamation of bogland and the production of " seed " potatoes. *J. Min. Agric. N.I.*, **4**, 1933.

12. SEED TESTING AND (PLANT DISEASE) DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Seeds.

Ultra-violet light tests in connection with purity of ryegrass species and strains.—The Gentner test developed in Belfast has become part of established official seed testing practice in a number of countries and is playing a prominent part in certification and strain grading work in certain Dominions as well as in Northern Ireland. It represents an important advance in seed testing technique.

A further largely increased accumulation of genetical data accruing during the year puts it beyond reasonable doubt that the fluorescence character is dependent upon a single genetical "factor." There is also further evidence for the suggestion already put forward that fluorescence is not linked with the agronomic characters which differentiate perennial from Italian Ryegrass.

To reconcile this absence of linkage with the observed fact that in practice the fluorescence content of certain ryegrass strains is a measure of their agronomic value, a hypothesis (1) has been put forward which suggests that major deterioration in perennial ryegrass strains is due to hybridisation with Italian ryegrass in the first instance, and that the content of fluorescence reactors is a measure of the extent to which hybridisation (and hence deterioration) has occurred.

In conjunction with the official stations in Copenhagen, Munich, and Stockholm, a series of tests was conducted upon selected ryegrass samples to ascertain the relation, if any, between the fluorescence reaction and the glume dentation used in the "Hellbo" test for distinction between perennial and Italian types. Results so far available suggest that the percentage of dentated seeds found by a Hellbo test is correlated with the percentage of fluorescent seedlings appearing in a Gentner test, but a dentated seed does not necessarily produce a fluorescent seedling nor does a fluorescent seedling necessarily imply a dentated seed. The correlation is sufficiently strong to permit the replacement of the Hellbo test by the less laborious and more precise Gentner.

Indigenous strains of grasses.

(i) *Strains already purchasable.*—The series of trials laid down in 1932 in collaboration with the County Instructors in Agriculture are yielding instructive results. At each of ten centres two half-acre plots were sown with a standard long ley mixture, the perennial ryegrass and cocksfoot being in one case of a good trade "indigenous" type and in the other ordinary "commercial". In 1933, the first harvest year, the following points emerged: the

" commercial " plots started growth earlier in Spring, which, together with a more erect habit of growth resulted in the indigenous plots looking " poor " at this stage. At hay time the discrepancy had largely disappeared and the indigenous plots presented a denser stand of more leafy produce. Hay yields from the " commercial " strains were on the average 2-3 cwt. higher than those from the indigenous. In autumn the latter plots looked relatively more promising from the permanent-pasture point of view. At two centres a third plot was added, sown with a mixture of the same species, but cheapened by using lesser quantities, the perennial ryegrass and cocksfoot again being " indigenous ". Botanical analyses in spring and summer, 1933, at one of these centres indicate that: (*a*) establishment of sown species in spring was best in the " commercial " plot and lowest on the " cheapened indigenous," (*b*) in autumn the population of sown species was best on the " indigenous " plot and lowest on the " cheapened indigenous ", (c) between spring and autumn perennial ryegrass and cocksfoot died out more on the " commercial " than on the " indigenous " plots.

Hay weights showed that under certain conditions the cheaper mixture was preferable, but that this did not hold universally. The crops were, per acre :—Hillsboro', County Down : Indigenous standard 33 cwts., Commercial standard 36 cwts., Indigenous cheapened 38 cwts. ; Strabane, County Tyrone : Indigenous standard 41 cwts., Commercial standard 47 cwts., Indigenous cheapened 37 cwts.

(ii) *New Strains.*—The plots sown with half pound samples of Northern Ireland and other selected strains, for " grazing " and seeding trials, referred to in the previous report were sown out in April 1933 and are now well established. Cutting tests will begin in Spring 1934. Meantime a number of the strains have already shown marked tendency to early maturity and winter weakness, notably " Domestic " ryegrass (U.S.A.) and " Wimmera " ryegrass (Australia).

(iii) *Industrial seed production.*—Some six acres of an élite strain of perennial ryegrass bred at the Welsh Plant Breeding Station were sown in spring 1933 for " bulking up " at the North West School farm, Strabane, County Tyrone, for the purpose of acquiring data as to seed productivity, date of ripening and so forth under Northern Ireland conditions and with a view to the introduction of such strains among commercial growers. This crop will come to harvest in 1934.

Practical value of damaged seedlings.—In collaboration with the official seed testing station Dublin, a series of laboratory and soil trials were made to determine the capacity for good plant production retained by seedlings whose roots were broken, in view of the severity of the International Seed Testing Association " rules " in regard to such seedlings. It was found that in all cases tried (including red, alsike and white clovers, trefoil, turnip, cabbage and

flax) seedlings a few days old injured by cutting away the radicle even above the region of root hairs, if planted in soil, produced perfectly good plants, and, in the case of turnips, no interference with " bulbing " resulted. A conjoint paper on this work is in the press.

Seeds mixtures for a littoral aerodrome.—In conjunction with the Belfast Harbour Commissioners a series of trial plots has been sown down on " slob " land in Belfast Lough (ground made up with several feet of mud dredged from the navigable channel) with the purpose of determining species capable of providing a solid " skin " suitable for a landing ground without necessitating too much mowing. Wild white clover seems successful on such ground and it is hoped a small fescue, a Poa or a bent, may supply the necessary graminaceous combination.

Determination of variety and strain by estimation of suction-force.—Experiments are in hand to determine the value in a grass-seed laboratory of Buchinger's " saugkraftmessung " method for diagnosis of species and strains by rate of imbibition of water (and hence of germination) from standard cane sugar solutions. Preliminary results suggest that the system offers possibilities of discriminating types of ryegrass but the usual difficulty arising from mould infection of glumes is being met with. Experiments in the elimination of this difficulty are in progress.

Weeds.

Sodium chlorate.—The cheap impure sodium chlorate referred to in the last report did not prove successful. Commercial pure chlorate is now in regular and general use.

Rushes.—A comprehensive system of experiments on methods of preventing and eradicating infestations of rushes by poison, manure, drainage, pasture management and mechanical treatments is in hand under a scheme of collaboration between all research departments of the Ministry, the Agricultural Institute, Hillsboro, and the County Instructors.

Title of paper issued during the year.

1. Linehan, P.A., and Mercer, S. P.: Fluorescence of *Lolium* in ultra-violet light. *Nature*, **131**, 1933.

C

HORTICULTURE AND GLASSHOUSE CROPS

13. Long Ashton Fruit Research Station, University of Bristol.

FRUIT CULTURE.

1.—Plant Nutrition.

(a) *Rootstock problems.*

Field experiments.—Records were continued on the trial plots of apple trees on selected layered stocks and graded seedling stocks at Long Ashton and the various local centres. Data concerning stock influence on growth, blossom formation and cropping are accumulating from the Worcester Pearmain and James Grieve trees at Long Ashton but at the other centres observations to date relate almost wholly to growth characters.

An additional trial of the layered rootstocks has been established at Long Ashton, comprising 186 bush trees of the variety Grenadier. Further plots of standard trees, variety Bramley's Seedling, have been commenced at outside centres as under: Perthyre, Monmouth, 68 trees; Pitminster, Somerset, 44 trees; Rodney Stoke, Somerset, 67 trees. Two further trials, using Bramley's Seedling as standards, have been arranged in Hereford and Worcester.

On the trial plot of Bramley's Seedling, Worcester Pearmain and Lane's Prince Albert on the Malling group of rootstocks it has been necessary to modify recording arrangements, detailed records being now taken only on Worcester Pearmain. Only half of the original Bramley trees now remain on the plot.

On the plum rootstock plot, rootstock and varietal effects continue as reported previously. Silver leaf has become very severe on the variety Victoria, where over 50 per cent. of the trees are affected.

Laboratory Work.—Further data relating to the effect of rootstocks in influencing the mineral constituents of various scion varieties—leaves, terminal shoots and fruits—have been obtained.

(b) *Factors determining the relation of growth and fruit bud formation.*

The following sections have direct bearing on various factors concerned in problems of growth and fruit bud formation.

Stock and scion relationships.—In the previous report reference was made to a comprehensive series of experiments designed to throw light on the nature and location of rootstock influence. Apple trees, as bushes and standards, are being grown with various combinations of vegetatively raised rootstocks, Malling Nos. 2, 9, 13 being used as rootstocks and intermediate stem pieces. Worcester Pearmain is the main scion variety employed, but Bramley's Seedling is used in the case of the standard trees. Detailed records will be continued for several seasons.

The above experiment has lately been supplemented by a further batch of trees, scion varieties Cox's Orange Pippin and Worcester Pearmain, which have previously been used to determine whether, in the nursery stage, the vigour of the scion could be stimulated by the use of strong-growing vegetatively propagated rootstocks. In the nursery experiment Malling No. 9 rootstock was employed as the common scion with Malling Nos. 2, 9, 12 and miscellaneous seedlings as rootstocks. Now that the nursery trees have been headworked, the plantation trees consist of two scion varieties on various rootstocks with the common intermediate stem piece, Malling No. 9 rootstock.

Further batches of bench grafted apple trees are being raised to extend the observations on the effect of scion varieties on root morphology. In addition to confirming previous results that the American varieties Winesap, Tetofsky, Delicious and Whitney significantly influence root morphology, the later experiments have shown that the English varieties James Grieve and Grenadier produce significant effects on root form. Results with Worcester Pearmain are rather indefinite although suggesting a scion influence.

The seasonal cycles of nitrogenous and carbohydrate substances in apple trees.

The investigations proposed include the effects of various orchard factors on the cycles, such as rootstock effect, cultural and manurial practices etc. During the past season a study of the seasonal cycles of the various constituents was completed in the case of two sets of apple trees, variety Newton Wonder, growing under two cultural systems, viz., grass plus spring nitrate and clean cultivation without nitrogen. The results show definite seasonal cycles for the various nitrogen and carbohydrate fractions and also no alteration of the general natures of the cycles by the two cultural systems, although the quantitative levels of constituents are affected by them.

In the coming season rootstock influences on the cycles will be studied.

Biennial Bearing of Apples.—The experiments on the apple variety Early Victoria have been continued as outlined in the previous reports and the results continue to confirm those of previous seasons.

Bark Ringing.—(see Section XII.)

Tree shaping and pruning.—The main systems of shaping and pruning adopted in this experiment have been outlined in previous reports. The trees are still young and only three or four varieties have reached the stage when appreciable crops may be expected. Attention so far has been concentrated in producing growths on which the various shaping systems may be based and it is only during the present season that satisfactory growths for shaping purposes have been induced in some of the more difficult cases. No further features of note have emerged during the season.

Cover Crops.—Records were continued on the apple plot where the systems grass + nitrate, grass + nitrate + mulch, and clean cultivation are being compared. The trees on the cultivated area are still the most vigorous in spite of the fact that the plot received no dressing of nitrogen. The " grass " effect on the trees under the grass systems of culture appears to be less marked than in the earlier years of the treatments, but further evidence is required before a definite statement regarding this point may be made.

The nitrogen contents of the terminal growths in the case of the variety Newton Wonder—the only variety examined—were found to be significantly less throughout a whole season, March 1932-March 1933, in the trees under grass than in those under arable culture.

(c) *Manurial experiments.*

Pot experiments.—The two experiments with apple trees, variety Bramley's Seedling, and one with the variety Worcester Pearmain were continued. In the Bramley experiments special attention was again given to the technique of watering and the addition of nutrient elements in relation to deficiency effects (3), whilst with the Worcester Pearmain trees a comparison of two grades of sand was made.

Laboratory investigations.—The chemical examination of strawberry fruits from various manurial plots has been continued with a view to determining the effects due to seasonal variations and to local influences. The plots concerned are located at Long Ashton Research Station, Hants. County Council Station, Botley, and Somerset County Council Station, Cannington.

The determinations have been extended to include dry matter and pectin.

Field experiments.

Experiments at Long Ashton.—No further plantings have been made during the season and work was wholly concerned with records on the established plots.

The gooseberries interplanted in the apple manurial plot are showing the effects of potash deficiency in a very marked way

and the trial provides an excellent demonstration of the manurial requirements of the gooseberry. The effects of potash deficiency on the apples, variety, Lane's Prince Albert, are also very striking on this plot. The outstanding point on the black currant manurial plots is also due to potash deficiency, although the effects of withholding nitrogen are also clearly shown, and it is possible that phosphorus deficiency is producing adverse effects but the present observations on this point require confirmation.

No point of note has emerged in the experiments on the time of application of manures to apples.

Experiments at other centres.—Observations were continued on the manurial plots at Cannington Farm Institute. No new point has arisen, potash deficiency continuing to be the outstanding feature on all classes of fruits—apples, gooseberries, black currants and strawberries. The data already obtained have been summarised (26).

The experiment on the production of Cox's Orange Pippin on poor land continues to show satisfactory progress of the trees under appropriate potash manurial treatment.

Soil moisture experiments.—(See Section XI).

(d) *Leaf scorch of fruit trees.*

Pot and laboratory experiments.

Rootstock Effect.—In the pot experiment on apple trees, variety Cox's Orange Pippin, the trees were fed with nutrient solutions from which potassium was omitted but the treatment appeared too severe to allow of differential effects due to rootstocks to be developed. Under the treatment the trees on all rootstocks failed to make appreciable growth and showed drastic effects of potash deficiency. An attempt will be made to revive the trees in 1934 and to test a less drastic potassium deficiency treatment in the following year.

Chemical investigations on leaves, stems and fruits.—The analytical work has been completed and the results are being considered in connection with pomological and soil data.

Potassium status of leaf scorch soils.—The first stage of this investigation has been completed and the results published (4). It is proposed to continue the work on special plots to be established at Long Ashton on which the movement of potassium (also phosphorus and nitrogen) will be followed under various manurial and cultural systems.

Field Experiments.

Observations and experiments in the field have demonstrated the all-important rôle of potassium in cases of leaf scorch under widely varying soil conditions. The main practical field problems

relating to the control of the disease have now been elucidated and attention will thus be given in the next stage of the work to intensive studies of points raised in the field investigations. Of these the movement and forms of potassium in the soil and problems of intake of the element by fruit plants will be first to be considered (5).

(e) *Lime-induced chlorosis.*

Further experiments were commenced on the control of lime-induced chlorosis in the field. The special object of the experiments has been to test the injection methods recently advocated by J. P. Bennett in California. After preliminary trials on methods of injecting liquids and solids, field experiments were carried out on apples, plums and pears of injecting solid iron citrate in March, just prior to the beginning of the growing season. The technique of Bennett was closely followed, dosages however being usually kept slightly lower than those recommended. The results over one growing season have been uniformly excellent, in some cases very large responses being obtained with trees which had been severely chlorotic, stagnant in growth and showing die-back for several seasons. It remains to show how long the effects will persist.

(f) *Storage qualities of fruits*—(see Section XI).

II.—Surveys of Fruit Soils.

A preliminary reconnaissance has been made of the soils in the cider fruit area around Martock in Somerset. The soils of this area will be included in a wider survey of Lower Lias soils to be carried out in the district.

III.—Investigations on Soft Fruits.

(a) *Strawberries.*

Cultural problems.—Problems of strawberry cultivation continue to be very complicated by the variety of abnormal and diseased plants which occur in all strawberry growing districts. The unsatisfactory position has held up many lines of investigation and has led to the concentration of efforts on pathological problems. At the same time it is essential to attempt to maintain production whilst awaiting the solution of the various troubles and the cultural programme is concerned with this point.

The main lines of investigation are as follows:

(i) Selection and propagation of promising strains of Royal Sovereign to build up healthy stocks;

(ii) Variety trials;

(iii) Clonal selections of Royal Sovereign and Oberschlesien with a view to studying problems of progeny and propagation;

(iv) Pollination problems of the varieties Royal Sovereign, Oberschlesien and Tardive de Léopold.

Pollination problems under (iv) have been of great practical importance in view of the fact that, owing to the failure of Royal Sovereign, large acreages of Oberschlesien and Tardive de Léopold have been planted out. In Long Ashton experiments under laboratory conditions (7), Tardive de Léopold has been shown to be wholly self sterile and useless as a pollinator, Oberschlesien only partly self fertile and a moderate pollinator, Royal Sovereign highly self fertile and an excellent pollinator for the other two. The investigations have been extended to field plantings where attempts are being made to ascertain the best planting systems in order to ensure adequate pollination where Oberschlesien and Tardive de Léopold are the main crops.

(b) *Raspberries.*

Cultural problems.—Nursery work has been continued with a view to obtaining clean stocks of various varieties for further variety trials referred to in the previous report.

Variety classification.—The work has been continued.

(c) *Black currants.*

Pruning.—The results in the pruning experiments on the varieties Boskoop, Baldwin, Edina and Seabrock confirmed those given in the previous report.

(d) *Red currants.*

Pruning.—The pruning experiment to compare light branch thinning with the normal spur pruning method has been continued. It still shows the latter system to be unsuitable for certain varieties such as Raby Castle and Fay's Prolific.

The trial includes several new varieties such as Laxton's No. 1, Perfection and Northern Star.

(e) *Gooseberries.*

Variety classification.—The work has been continued.

Variety trial.—Further records were obtained in this experiment. The blowing out of shoots previously experienced appears to have been overcome by summer pruning treatment.

IV.—Fruit Breeding.

No point of note has occurred in the investigational work during the season.

Under the Seedling Distribution Scheme of the Station, applications for propagating material were received from about 20 sources.

The varieties in greatest demand are the blackberry, Ashton Cross, the two black currants, Mendip Cross and Cotswold Cross and the pear, Bristol Cross.

Wisley Variety Trial Scheme.

The apples are still too young to determine their ultimate merits, the oldest on the plots, Laxton's Superb and Herring Pippin being only 5 years from planting.

Of the raspberries only Norfolk Giant and Brockett Hall have been retained for further tests.

The black currant experiment to determine the experimental error in variety trials with this fruit has been concluded and the results have been forwarded to the co-ordinating committee for analysis. Of the black currant varieties tested it has been noted that Davison's Eight is very susceptible to frost and adversely affected by sulphur spraying under Long Ashton conditions.

V.—Pests and Diseases and their Control.

(a) *Reversion disease and big bud of black currants.*

Records on the spread of reversion disease on the plot containing infection centres continues to show that the spread of the disease occurs in sporadic fashion and cannot be simply related to the original infections. Some development of big bud was observed and it is of interest to note that the infections occurred mainly on bushes which have been reverted for several seasons. Possible vectors of reversion disease are being tested on seedling black currants grown under sterile and insect free conditions.

(b) *The control of Byturus tomentosus on raspberry and loganberry* (8, 9, 10, 11).

A comprehensive series of spraying experiments was again carried out on the control of this pest, the main objects being as follows :

(i) To ascertain the degree of control to be obtained from freshly prepared emulsions of high quality Pyrethrum flowers and to compare different types of Pyrethrum emulsions.

(ii) To determine the degree of control possible from late applications of efficient spray fluids—just before ripening commences—in a season when the beetles did not assemble in number in the flowers at any particular period.

(iii) To test the efficiency over a further season of derris-soap washes and derris dusts in single and double applications.

(iv) To determine the toxicity of barium silicofluoride washes and dusts applied at different stages, and to ascertain the residues of fluoride left on the berries from the use of this material.

(v) To test the toxicity of a proprietary aliphatic thiocyanate preparation.

The main results may be summarised as follows :

(i) Freshly prepared Pyrethrum emulsions at high concentrations of pyrethrins were as efficient as derris preparations, which provided almost complete control of the pest.

(ii) Two applications of derris dust were practically as efficient as derris washes, since control was again almost complete.

(iii) One application of barium silicofluoride (10 lb. per 100 gals.) produced a result similar to that obtained from two applications of a derris-soap wash.

A high degree of control was also obtained from the use of a barium silicofluoride dust.

In all cases where barium silicofluoride was used the residue on the berries at harvest was considerable.

(iv) Two applications of the thiocyanate preparation tested against barium silicofluoride provided control similar to one application of the latter wash at a strength of 5 lb. per 100 gals.

The most important practical point which emerged from the investigations was that, when beetles do not assemble in large numbers in flower buds and open blossoms, the most reliable method of control is by late applications of insecticides on the larvae not earlier than two weeks after petal fall. The experiments also demonstrated that a high degree of control can be obtained from Pyrethrum emulsions containing high concentrations of pyrethrins when certain precautions are observed, a fact of interest in view of the variability of results from such preparations in commercial practice.

Although excellent control was obtained by barium silicofluoride preparations, the use of this material cannot be recommended until it is shown that the substantial residues left on the berries are not harmful to consumers.

(c) *Apple sawfly* (*Hoplocampa testudinea*).

Sawfly has become a great menace to apple growers during the past few seasons and for this reason an extensive programme of experiments was planned, the results of which have made possible the formulation of an efficient spray programme against the pest. The scheme of experiments was partly carried out in commercial plantations and the remainder at the Long Ashton Station. The following constituted the main points investigated :—

(i) The relative efficiencies of single and double applications of nicotine washes after petal fall.

(ii) The effect of adding lead arsenate to the nicotine preparations.

(iii) The effect of incorporating with nicotine, lime sulphur, oil emulsions and lead arsenate, on the efficiency of the nicotine as a control of sawfly.

(iv) The degree of control of certain other insect pests and apple scab, by the above incorporated materials, when used in this way.

(v) The degree of susceptibility to sawfly of different varieties.

(vi) Methods of determining optimum spraying dates.

(vii) Points of importance in spraying technique.

The results obtained in the experiments were considered of such great importance to the industry that the practical applications have already been given considerable publicity among fruit growers (12). The more important conclusions arrived at may be summarised as follows :—

(i) Single applications of a nicotine wash are only likely to be highly efficacious when less than 10 per cent. of the flowers are affected. Two applications will always be required when the infestation is greater than 20 per cent. In a case where the original infestation was 96 per cent. a double washing reduced this to 2 per cent., whereas a single application only decreased the value to 36 per cent.

(ii) The addition of lead arsenate increases the efficiency of the nicotine preparation against sawfly and the incorporation of lime sulphur does not affect the toxicity of nicotine. The effect of adding oil emulsions requires further examination.

(iii) The critical period for the application of sprays to control sawfly is within 14 days of petal fall, which coincides with an appropriate period for applying washes against capsids, red spider, codlin moth and apple scab.

Control of sawfly, capsid, red spider and scab may be effected by a lime sulphur-nicotine wash with an appropriate wetter (e.g., Agral I, Lethalate Wetting Preparation) whilst a nicotine-oil emulsion may be used against sawfly and red spider.

(iv) Mid-season blossoming varieties are most susceptible to sawfly attack, Worcester Pearmain, Charles Ross, Rival, James Grieve, and Ellison's Orange being particularly so.

(v) A simple method of determining spray dates was evolved, based on the facts that sawfly eggs may be killed by a nicotine spray within the 4 day period prior to hatching and that better control is obtained with a single spray by spraying before the majority of the eggs are hatched.

(vi) Spraying technique is of great importance in attempting to control sawfly. It is essential that the blossoms and fruitlets be thoroughly wetted. To accomplish this satisfactorily special attention must be paid to the use of an efficient wetting agent in the spray fluid and to the manner of applying the wash. Correct timing of the spray applications is fundamental to success, which means that in addition to correctly determining spray dates, the work must be done very quickly where considerable acreages are involved.

(vii) The best programme appears to be as follows : a first application, consisting of nicotine + lead arsenate at the commencement of the hatching period of the eggs, followed by a second application, 7 days later, of nicotine + lime sulphur. In both cases an efficient wetter must be incorporated.

(d) *Red spider* (*Oligonychus ulmi, Koch*).

Experiments on the incorporation of lime sulphur and oil emulsions in omnibus washes have in view the control of this pest (13). (See later sub-section on mixed washes.)

(e) *Strawberry pests.*

Tarsonemid mite.—The Station beds were severely infected with this pest during August, 1933, and the opportunity is being taken of attempting to control it on runners from infected plants by various means. The following treatments are under test :—

(i) Hot water treatment of runners prior to planting at 110° F. for 20 minutes.

(ii) Soaking of runners in a pyrethrum-white oil emulsion (1 per cent. pyrethrum flowers and 2 per cent. white oil) for 5 minutes.

(iii) Soaking of runners in emulsion of 2 per cent. lime sulphur and 2 per cent. white oil for 5 minutes.

A crinkled leaf form of plant is also under observation. Runners have been taken from affected plants for comparison with others from plants not showing the symptoms. The cause of the condition is unknown : the disease will be examined in relation to eelworm and mosaic.

(f) *Die-back in plums* (*bacterial stem canker*).

Trials of the value of resistant stocks in cases of die-back in Victoria and Burbank's Giant Prune have been continued at Fladbury, Worcestershire. The two scion varieties are now growing as headworked trees on Pershore Egg, Mussel and Peach stocks. Further batches of trees are being raised, using Kentish Bush as rootstock and stem variety. No cases of die-back have occurred on any of the head-worked trees in the experiments.

(g) *Die-back in apples.*

The common *Cytospora* of apple trees has been shown to be the imperfect stage of *Valsa ambiens* and it has been demonstrated that it can invade healthy trees when once established in dead areas. The fungus is capable of causing much injury to moribund trees (14). The role of certain other semi-parasitic fungi is under investigation.

(h) *Apple canker.*

An attempt is being made to ascertain the measure of control which may be attained over the canker fungus on apple trees in the nursery stage by means of spraying measures. A batch of 400 Worcester Pearmain and Cox's Orange Pippin trees are being treated this autumn.

(i) *Apple and pear scab.*

Investigations on the processes of infection and invasion of the pear scab fungus and the subsequent reaction of the host plants were concluded and the results published (15). It was shown that shoots are the main source of spring infections, as in the apple, and that the production of spores from shoots was at a maximum in March and April. In field trials on a commercial scale in a wet season two sprayings were insufficient to give a satisfactory control, whilst six sprayings increased the proportion of clean fruit from 2 to 60 per cent.

Observations on spray damage showed that Doyenne du Comice was susceptible both to sulphur and copper damage.

Attention was given to the practicability of controlling scab in various mixed washes (13). The two chief points examined were the use of combinations of lime sulphur-nicotine and lime sulphur-white oils. Both combinations appear satisfactory. Scab spraying in cider orchards has not previously been carried out. Spraying was carried out on typical cider orchard varieties in the Long Ashton orchard with lime sulphur at the pre- and post-blossom stages. Data were obtained relative to costs of spraying, control of scab and red spider and the sulphur sensitiveness of several important varieties.

(j) *Raspberry diseases.*

Mosaic.—The elimination of this from Research Station stocks by rogueing methods has been continued along the lines previously reported. Stocks of raspberry seedlings are being raised under insect-free conditions for investigations to determine possible insect vectors of raspberry virus diseases.

(k) *Strawberry diseases.*

Arising from observations in the Hampshire and West Midlands strawberry areas a systematic examination of root rots of strawberries has been commenced. Many fungi have been isolated from diseased forms. The parts played by virus diseases in degeneration of strawberry plants is under investigation. Seedlings are being raised under sterile, insect-free conditions and possible vectors and other means of transmission tested. A method of controlling " hard rot " caused by *Stagonospora Fragariae* has been described (16).

(l) *Blackberry rusts.*

Two rusts of blackberries, *Kuehneola albida* and *Phragmidium violaceum* are receiving attention. In the case of the former of these the life history of the fungus and the course of infestation are being examined. At Long Ashton the rust does not attack loganberries or dewberries and only rarely infects Himalaya berries and the Black Diamond variety. In affected plants, in spring, elongated, bright yellow pustules burst through the epidermis of the year old stems and continue to produce spores until the autumn. The leaves, leaf stalks, sepals and sometimes the fruits show infections from June onwards and any leaves remaining during the winter carry spores until the spring. The fungus in the stem grows principally in the cortex but may occur in the medullary rays and pith. No control measure has yet been developed.

Phragmidium is common on wild blackberries but so far only one serious case has been reported under cultivated conditions. Methods have been worked out for distinguishing between uredospores of this species and of those of *Kuehneola*.

(m) *Fruit spots and rots of apples and pears.*

A systematic study of the biology and control of fruit spots and fruit rots is in progress. *Phytophthora Syringae* and *Gloeosporium album* have previously been investigated and *Sphaeropsis malorum* and *Gloeosporium fructigenium* are now being considered. Special attention is given to the possibility of the occurrence of the fungi on the vegetative parts of the tree with a view to control measures by spraying.

(n) *A "canning" fungus.*

A mould resistant to canning processes, provisionally identified as *Byssochlamys fulva*, has been kept under observation for the Campden Research Station. It occurs chiefly on strawberries but has been reported on most fruits excepting damsons.

(o) *Combined Sprays for Summer Use* (13).

This work was continued with a view to evolving combination washes to serve as (i) mixed insecticides and fungicides, and (ii) mixed insecticides. In the former series of trials the aims were to ascertain the control to be obtained on such pests as apple sawfly, capsid bugs and red spider and on the scab fungus, and to examine the extent of foliage damage resulting from the use of the washes. The success obtained with such washes in controlling apple sawfly and scab has been previously mentioned.

In the foliage damage experiments, combinations of white oil and lime sulphur at varying strengths were applied at green bud, pink

bud and post-blossom stages to apples and an " omnibus " post-blossom wash containing lime sulphur, white oil, calcium arsenate and nicotine was also tested on this fruit. In the latter experiment serious damage occurred to the varieties Allington Pippin, Bramley's Seedling, and Charles Ross when calcium arsenate was included. The mixed insecticides washes included combinations of lime sulphur and nicotine, lead arsenate and nicotine, mineral and vegetable oil emulsions and nicotine, mineral oil emulsions and lead arsenate, mineral oil emulsions and Pyrethrum extract, mineral and vegetable oil emulsions and rotenone, Pyrethrum extract and Kerosene, an aliphatic sulphocyanide and Kerosene. The washes were tested on apple sawfly, capsid bug, raspberry beetle, woolly aphis, red spider, strawberry tarsonemid mite and willow beetles.

(p) *Influence of " wetters " on the toxicity of nicotine and lime sulphur.*

Experiments on such pests as the apple sawfly have demonstrated the great importance of efficient wetting agents. In sawfly experiments the effects of wetting substances such as Lethalate wetting preparation, soap, and mineral and vegetable oils in nicotine washes, have been compared. Soap was found to be inferior to the other substances where difficult wetting problems were presented. Lime sulphur washes were greatly improved as acaricides against red spider by the addition of appropriate wetters.

(q) *Effect of spreaders on arsenical spray fluids.*

The effect of varying amounts of different spreaders on the quantities of arsenic deposited on willow foliage was determined. It was found that the amount of deposit reached a maximum with increase in the amount of the spreader and then decreased. Varying either the spreader or the nature of the arsenate had well defined effects on the amount of the initial deposit and its adherence to the leaves.

(r) *Pyrethrum products.*

The investigations described in the previous report were continued. The various products, mostly related to the pyrethrins, which have been prepared were tested for toxic properties on winter moth larvae and *Gnathocerus Cornutus*. Some of the compounds possessed definite toxic properties but insufficient to justify their use as contact insecticides.

(s) *Fungicidal action of sulphur.*

Studies of the behaviour of the living plant cell in relation to sulphur are being continued. Some further attention has also been given to the parts played by particulate sulphur and sulphur vapour respectively in the interactions concerned. Preliminary studies on the nature of sulphur-sensitivity of certain varieties of fruits have been begun.

(t) *Spraying technique* (17).

Further progress has been made in attempting to develop a mobile spraying outfit suitable for modern commercial requirements. A mobile unit has been procured and experiments carried out with a view to developing its use in plantations. The mobile system was compared with an efficient " piping " method. The trials suggest that the mobile system may be relied upon to speed up spraying under most circumstances and to cheapen labour costs. The new machine has also been used for testing spraying accessories, especially spray guns, and it has been possible to improve the " reach " of the usual pattern of gun by modifying the nozzle disc.

FRUIT PRESERVATION AND PRODUCTS.

VI.—The Chemistry of Fruits (18)—(see Section XIII).

VII. The Physiology of Fruits (see Section XIV).

VIII. Cider Investigations.

Cider and perry competitions (19).—These were continued. There were 119 entries spread over six classes. An outstanding feature was the unusually high astringent flavour of the sweet and bittersweet ciders.

Single variety trials (19).—Four single varieties were tested from trial orchards: Brown Snout from a Worcester orchard and Knotted Kernel, Dabinett and Lambrook Pippin from the Research Station orchard. All yielded good ciders. A variety obtained under the name of Medaille d'Or, but quite distinct from the variety known by that name at Long Ashton, was tested and yielded an excellent bittersweet cider.

Utilisation of cull apples for cider making.—Successful attempts were made to improve the cider qualities of juices from culinary and dessert variety culls by maceration with pressed pomace from bittersweet varieties of vintage quality. The procedure resulted in alteration in the characters and qualities of the juices.

Pomace drying.—A pomace drier has been installed and experiments commenced to determine the economic aspects of drying pomace.

The resistance of metals to cider.—Tests were made with various newly introduced metals. Of these, acid resisting bronzes, austenitic cast irons and inco chrome nickels were found to be entirely unaffected by cider. Since these products are all easy to work they should be suitable for use in cider making appliances.

Astringent principles of cider apples.—Impure crystals of an extremely astringent compound have been isolated from a bittersweet cider.

Centrifuging and filtration of juices and ciders.—Attempts have been made to determine some of the effects produced by the centrifuging of juices and ciders. The following points received special attention :—

(i) The effect of centrifuging on the yeast population. The centrifuge was found to remove almost the whole of the yeast crop, the larger yeast cells in particular being withdrawn.

(ii) The relative effects produced by centrifuging on ciders of varying gravities. Juices were used with gravities ranging from 1·037 to 1·007. The largest effects were produced on juices of the lower gravities, fermentation being practically inhibited when the gravity was below 1·024.

(iii) The effect of double centrifuging. Double centrifuging was most effective when the juices were treated after some fermentation had taken place. Treatment at gravity 1·030 and again at 1·025 checked fermentation for a considerable period.

(iv) A comparison of the flavour and aroma of centrifuged and filtered ciders and the relationship of the characters to chemical composition. The work is still in the initial stages and attention is specially directed to the possible relationships between aroma and esters content. The pectin contents are also being examined.

Rate of decomposition of pectin compounds in fermenting juices.—Fermentation appears to cause a rapid decomposition of pectin in apple juices, in some cases only a trace remaining after ten days of fermentation. The course of pectin decomposition in various types of juices undergoing fermentation is being followed.

IX. Fruit Products.

Fruit syrups.—Juices and syrups from low grade tomatoes and gooseberries were prepared. An unpleasant flavour resulted with tomatoes when the fruit was heated to boiling point. The gooseberry syrup was an attractive product.

Fruit concentrates and wines (20).—Quality tests were carried out on products mentioned in the previous report. Sweet wines were superior to the dry ones, loganberry, strawberry and rhubarb products being of high quality. Wines prepared from twice pressed fruit were inferior to those made from the first pressing.

Clarification of fruit juices by enzymes (21).—Two enzymes were tested for clarification processes in fruit juices. One of these which is specific to pectin and cellulose complexes was of great value but the other which acts on protein compounds increased the rate of fermentation.

Non-alcoholic apple juice (22).—Several lines of work relating to this product were pursued. The natures of the beverages

which may be obtained from low grade, windfall and scabbed fruits of the following commercial varieties were determined—Bramley's Seedling, Newton Wonder, Annie Elizabeth, Lord Hindlip, Ontario, and Allington Pippin. Whilst some of the products lacked character, they appeared suitable to form the basis for flavoured apple drinks. The effects of germ-proof filtration and pasteurisation on the chemical characters and flavours of apple juices were compared. Pasteurisation yielded more deeply coloured products but the flavours were inferior to those obtained by filtration.

Attempts to remove harsh flavours from culinary apple juices by reagents such as gelatin, tannin, albumen, pectinol, etc., were unsuccessful. The treatment of thin culinary juices by soaking with dried apple pomace resulted in the removal of tannin from the juices.

The problem of storing alcohol-free apple juices in casks for maturation has not yet been solved, after-fermentation occurring in all cases tried.

Fruit liqueurs.—Liqueurs have been prepared from loganberry, raspberry and strawberry wines, the first giving an attractive product.

Use of pulps for gel formation.—Plums and tomatoes have been used for the preparation of hard gels.

Economics of fruit products manufacture.—Data are being collected relative to some factors concerned in the preparation of various fruit products with a view to determining the commercial feasibility of manufacturing products from various raw materials.

Distribution of SO_2 in preserved fruits.—Comprehensive investigations were pursued to examine the distribution of SO_2 in the different parts of fruits preserved by the cold SO_2 process.

Fixed and free SO_2 has been distinguished and in the case of plums distribution of total SO_2 has been followed in skins, pulp and stones. Fruits containing seeds offer difficulties in estimating the distribution of SO_2. A special technique for estimation has been developed.

Use of commercial pectins for jam making.—Following on the previous year's results, trials with a selected brand of commercial pectin were carried out to determine its value in the making of jams by boiling and " cold process " methods with raspberries, black currants, gooseberries, cherries and strawberries. Satisfactory results were obtained, being particularly good with " cold process " raspberry jam.

X.—Willow Culture and the Utilisation of Willows.

Variety trials.—These were continued. Selections were made with a view to their suitability for various kinds of basketry, particularly fruit baskets. Several cultural treatments were compared with special reference to their costs.

Pests and diseases.—(a) *Insect.*—Trials were repeated on the Station beds with derris washes to control the beetle *Phyllodecta*, and the sprays again proved very efficient. Derris undoubtedly provides an excellent control of this pest.

(b) *Fungus.*—Substantial progress has been made in investigations on the biology and control of the basket willow rust *Melampsora amygdalinae* and two papers have been published (23, 24). Field trials with sprays in 1933 were not successful owing to the absence of the rust under the prevailing dry weather conditions.

Other willow rusts are being examined, especially one on cricket bat willow and one on *Salix daphnoides*.

A prevalent and destructive canker of cricket bat willows is also under observation.

Mixed insecticidal and fungicidal washes for basket willows.—Laboratory scale tests were made with a mixed wash containing Bordeaux mixture, mineral oil, nicotine, sulphite lye and lethalate wetting preparation to determine its suitability for application to *Salix triandra* willows. Satisfactory results were achieved when the concentration of the wetting agent was carefully adjusted, a uniform distribution of the liquid on the foliage, without damage, being obtained.

The culture of Salix alba, var. caerulea (Cricket bat willow) (25).—The main experiments carried out concerned the relative values of different methods of producing sets; methods of producing rooted sets; and the relative values of rooted and unrooted sets in tree production.

In collaboration with the Imperial Forestry Institute, Oxford, and The Forest Products Research Laboratories, Princes Risborough, sets were taken from mature trees for propagation. The timber of the parent and progeny trees will be tested at Princes Risborough to determine whether the quality of the timber in the original trees is shown in that of the progeny. The tests should show whether it is desirable to select parent trees from which to propagate sets.

Studies of the growth marks in bat willows were continued.

FACTORS INFLUENCING THE STORAGE QUALITIES OF FRUITS.

XI.—Pot Culture Experiments.

Deficiency experiments.—The experiments described in the previous report were continued along the lines indicated therein. Further attention is required to points relating to water supply and to nutrient levels where deficiency treatments are applied. The trees are all making satisfactory progress.

Soil moisture experiments.—The experiment with apple trees, Bramley's Seedling, were continued but in view of the previous year's results, which suggested the importance of temperature as well as of soil moisture, only half of the trees under each treatment were grown in the greenhouse as in previous years and the remainder under open air conditions.

The trees under the two temperature levels are responding differently, those under low soil moisture treatment making much better growth under outdoor than indoor conditions. The outdoor high moisture trees tend to show low nitrogen symptoms, much more so than the high moisture indoor set.

A problem of nitrogen level due to the two moisture treatments has appeared and it seems that it will be necessary to supply extra nitrogen to the high moisture series.

Only a moderate crop of fruit was obtained during the season, but the characters were similar to those in previous seasons. Abnormally high temperatures were again experienced under the glass house conditions, due to heat waves, and once more these resulted in the development of cork and water core.

XII.—Storage Experiments.

Storage investigations were continued along the lines followed in previous seasons.

In the storage programme special attention was given to problems in connection with bark ringing and rootstock effect. In the work on bark ringing the main object was to ascertain the effect of using oiled wraps against the flesh breakdown and superficial scald which follow from ringing when fruits are stored at 1° C.

The varieties Bramley's Seedling and Newton Wonder were used in the majority of cases. The point under investigation was of special interest in the case of Newton Wonder, which variety usually breaks down in the manner known as "core flush." Ringing has the effect of causing the variety to scald severely, and breakdown under these circumstances usually follows scalding, commencing in the cortex region. It was thought that, if scald could be prevented in ringed fruits by means of oiled wraps, the bad effects of ringing on storage breakdown might be largely overcome or keeping quality might even be improved over that of "not ringed" fruits. It was found, however, that, whether wrapped or not wrapped, "ringed" fruits were inferior in keeping quality in the Low Temperature Store to comparable "not ringed" fruits. Moreover, the influence of ringing in producing Superficial Scald appeared so great that adequate protection was not effected on "ringed" fruits by the use of the best grade of oiled wraps.

In the experiments on rootstock effect fruits were used from special plots established by the East Malling and Long Ashton Stations and it is proposed to repeat the tests over several seasons.

The work on the samples from the plots at the East Malling Station is of special importance, since it is possible to obtain samples of two varieties, Bramley's Seedling and Worcester Pearmain, on several rootstocks under four manurial treatments, viz. N + K; N; K; no manure.

Other points under examination were potash deficiency, general manurial treatment, root pruning, branch pruning systems, terminal and lateral fruits and fruit thinning. A "time of picking" experiment in relation to the keeping qualities of Comice pears was also carried out. It was found that time of picking did not affect appreciably the important point that Comice fails to ripen if kept at 1° C. longer than a certain critical period.

XIII.—Chemical Investigations.

Chemical work was continued along the lines described in previous reports. Data from several seasons' experiments relating to the effects of various orchard factors on the contents of ash, potash and phosphorus in the fruits have been analysed. (1)

XIV.—Physiological Investigations.

A detailed investigation into the behaviour of apples after picking, when picked at different stages in their maturity, was carried out. Apples from trees which had been ringed, trees which had been grown under grass cover crop, and trees on which fruit thinning had been carried out, together with their respective controls, were picked at three different times and their behaviour under ordinary storage with respect to the following aspects of their metabolism followed :—(*a*) Loss of total weight, (*b*) progress of softening, (*c*) change in catalase activity, (*d*) change in total nitrogen content, (*e*) change in the equilibrium of sugars, and (*f*) change in the content of acid hydrolysable insoluble matter.

From an examination of those results indications have been obtained that fruit from the treated trees is maturing more slowly during its growth on the tree than is that from the control trees.

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14. EAST MALLING RESEARCH STATION.

POMOLOGY.

In Relation to Tree Fruits.

(a) *Rootstock investigations.*

Apples.—One of the rootstock trial plots consisting of Bramley's Seedling interplanted with Worcester Pearmain has been thinned. The Worcesters were removed in order to allow of full development of the Bramleys. One hundred and twenty-five trees were carefully lifted and provided a unique opportunity of securing root, stem and branch weights as well as detailed records of the thirteen

year old root systems of some sixteen varieties of " Paradise " rootstocks, stem worked with a single scion variety. Only one tree was found to have " scion rooted." The danger of trees " scion rooting " especially on Jaune de Metz (No. IX) rootstock when the " union " is planted at or below ground level was recorded in a bulletin (8).

The complete records of the original apple rootstock trials show that as the years pass rootstock influence becomes accentuated, but that the reactions of cropping upon " vigour " are now suggesting the need for some qualifications of the original method of grouping.

Analysis of rootstock influence, including the reciprocal effect of scion upon root.—The series of Lane's Prince Albert Trees, stem worked and root worked on vegetatively raised rootstocks and upon seedling roots, has made good growth this season, and records on comparative vigour of growth and axillary fruit bud formation should soon be available.

The microscopical examination of the stock stems and roots of a further set of bench grafted Lane's Prince Albert apple trees worked on Nos. II, IX, XII and seedlings, has confirmed the results previously obtained and, in addition, has given some new information on the comparative anatomy of stems and roots above and below ground level.

Pears.—A full account has been published of the work begun in 1917 upon the " free " or seedling rootstocks for pears (19). This article deals with their description, selection, vegetative propagation and preliminary testing, and shows a considerable range of difference in vigour, early blossom formation, as well as definite cases of incompatibility.

The lifting of a large series of pear varieties worked upon different varieties of Quince and Pear Seedlings has brought into prominence the question of " scion rooting," and offered material for study in considerable detail. " Incompatible " stocks readily induce the habit, and varieties of pear, known to be partially incompatible with quince, scion rooted fairly readily. In both cases, trees of peculiar habit of growth with little blossom resulted (8).

Plums.—Some 350 thirteen year old plum trees, which formed the original rootstock trial of 10 widely different varieties upon seven different types of stock had to be removed to allow for the development of interplanted pear experiments. Full advantage was taken of this grubbing which allowed the taking of total tree weights as well as detailed observations upon the root systems.

Peaches.—The trained trees of Hale's Early planted against a board fence failed to set a crop. Particularly favourable weather conditions appear to be required for the setting of the fruit.

Cherries.—(i) *Acid cherry* (*Prunus cerasus*) *scions.*—A report on cherry rootstocks, and their influence of the Morello scion, has been published.

(ii) *Sweet cherry* (*P. avium*) *scions.*—Owing to the death and injury of a number of trees in the rootstock trials with sweet cherry scions from bacterial die back, the records so far collected are being examined statistically, to ascertain how far the trial is still likely to be of value.

Propagation.—The search for new rootstocks continues and intensive nursery trials of new apple and plum stocks have been planted together with existing commercial varieties.

Two hundred and eighty-eight new seedling apples, one hundred and seventy-nine of which were raised at the John Innes Horticultural Institution and one hundred and nine at East Malling from crosses between the variety Northern Spy and the stocks No. I, II and XII, after proving immune to the attacks of woolly aphis under greenhouse conditions, have been planted out for propagation tests.

The thirty groups of seedling prunus, presented by the John Innes Horticultural Institution in 1931 and collected from the Caucasus, which were budded with the variety Czar in 1932, have all produced excellent maiden trees and so far no sign of incompatibility is apparent amongst any of the groups.

The three varieties of apple " stem-builders " obtained from Germany and budded in 1931 upon seedling apple, No. IX and No. XII rootstocks have been run up for a further season. Many of the trees on No. XII exceeded a height of ten feet at the end of the second year whilst the majority of the trees on No. IX were less than seven feet in height and these last have grown in a curve away from the perpendicular. All the trees will be grafted this spring at standard height with single scions of commercial English varieties.

Eight 13 year old trees of Stirling Castle have been " porcupine " grafted with Worcester Pearmain with striking success. This method of " overworking " as previously used in Tasmania, should prove a ready means of changing over unsuitable varieties to those which are more remunerative.

The preparation of a series of plum trees having frameworks of a variety resistant to bacterial canker has been continued.

The series of nursery technique trials inaugurated in the spring of 1932 has been extended to include nursery staking trials. It would appear that rubber budding-strips are at least as useful for tying purposes as raffia and may prove to be preferable in regard to absence of the risk of constriction from the region of the inserted bud (18). So far the presence or absence of wood in the bud shield of apples appears to matter little as regards the resulting stand of trees in the nursery.

The experiments on the propagation of fruit tree rootstocks by means of hardwood cuttings and root cuttings have been continued.

(b) *Root development investigations.*

The observation of growing roots in the orchard, by means of observation trenches with glass windows fixed against the soil

has been continued. Weekly records of period, amount and position of new root growth have been obtained on mature apple trees on three different rootstocks. Records have also been obtained of the " suberization " of the roots or development of a cork layer which cuts off the absorbing root hairs. Some idea of the length of time during which a particular rootlet absorbs in one spot has thus been obtained. As the records extend over three years in one trench and two years in three others, it is now possible to note how some roots remain, thicken and produce lateral roots in later years, while others, particularly the fine laterals, die, shrivel up and disappear through the action of insects and soil organisms.

Records of soil temperature and moisture have been correlated with the root growth. These records suggest that the root growth varies directly with the soil temperature so long as soil moisture is sufficient. A deficiency of soil moisture is reflected very rapidly in lessening of root growth.

To determine the exact effect of light on the roots a special trial was carried out with root boxes having twelve observation windows subjected to various light conditions. This has shown that roots will grow in full daylight, though they are severely checked thereby. Short intermittent exposures check the roots much less, though there is an indication that slight checking may occur.

Some new studies on the growth of strawberry roots in " observation boxes " are of particular interest in connection with the strawberry root rot which the pathology section is investigating.

Several of the soil moisture meters developed here in connection with the root studies have been in operation throughout the season, and have given very interesting information concerning loss of water from the soil by evaporation and through absorption by tree and grass roots.

Tree excavations.—The root systems of two mature plum trees on Myrobolan stock were excavated in detail by the " block " method. It was found that although the main roots were shallow there were vertical roots descending to the rock, reaching a maximum depth of 7 ft. 6 ins.

Two pear trees interplanted with the plum trees were also excavated.

Reports were issued on " The root development of an apple tree in a wet clay soil " (9), and on " Pear, gooseberry and black currant root systems under different soil fertility conditions, with some observations on root stock and scion effect in pears " (10). These showed the relationship between the root system and various soil conditions, and threw further light on questions of manuring, cultivation and drainage.

(c) *Investigations in biennial bearing.*

These have been continued.

(d) *Double working of fruit trees.*

Further data on the influence of intermediate scions on the cropping and fruit quality of apples have been collected.

The crop of pears was too light and irregular in 1933 to yield data of much value. The nursery trial of double worked pears has made satisfactory growth.

(e) *Investigations into the non-setting of the blossom of certain varieties of pears.*

Stem ringing, carried out on certain trees of Pitmaston Duchess in spring, 1932, definitely increased the number of axillary fruit buds which blossomed in 1933, but does not appear to have affected the number of terminal and spur fruit buds. The set of fruit in 1933 was very light throughout, and does not appear to have been noticeably increased by ringing.

The dehorned and top-grafted trees of Doyenne du Comice produced in 1933 very little blossom and scarcely any fruit.

Whilst the crop of Marie Louise was much lighter than that of 1932, the spur thinned trees again produced a slightly smaller number of fruits than unthinned trees; their fruit was 16 per cent. larger, and approximately of equal total weight to that of unthinned trees. The " set " of blossom was more than twice as great on the thinned as on the unthinned trees.

The experiment on the effect of three different methods of pruning on growth and cropping is being continued.

(f) *Pruning.*

Apples.—Winter spur thinning has again increased fruit size, sometimes at the cost of a small reduction in crop. The method of spur thinning seems largely immaterial; when applied to trees bearing large numbers of fruit buds, any reduction in the number of fruit buds results in larger fruit. Two years work, however, have shown that large, well developed fruit buds produce more and larger fruits than small buds, even after allowing for the failure of some of the latter to blossom.

Dehorning has very considerably reduced the crop of Lord Derby and Bismark, but markedly increased the size of the fruit. Trees of Lord Derby dehorned two or three weeks before blossoming in 1933 showed distinctly more leaf scorch than similar trees dehorned one year earlier.

Pears.—The older series of pears under differential winter pruning treatments is still being studied in relation to the pruning and its influence on the setting and quality of the fruit. The sets of trees that have hitherto been left unpruned are now being thinned and spur pruned.

Cherries.—The Morellos dehorned in March, 1932, bore a moderate crop in 1933; their fruit was very much larger than that of any comparable trees not dehorned. It is proposed to dehorn the remaining trees in the older Morello plot in the winter of 1933-34.

(g) *Fruit thinning.*

Plums.—A light crop again prevented any further experiments being done in this connection.

Apples.—The experiments previously referred to have been continued.

(h) *Manuring.*

Apples.—The apple manurial trials in progress can be grouped under three headings :—(i) The renovation of unmanured trees, (ii) the treatment of trees in grass, and (iii) the treatment of young trees from planting.

In the first two groups the trials have been carried out on trees of Bramley's Seedling and Worcester Pearmain worked on a wide range of "Paradise" rootstocks and now fourteen years old. In the third group the trial is more extensive and consists of Cox's Orange Pippin and Beauty of Bath on four representative rootstocks.

(i) *The renovation of unmanured trees.*—Growth on the plots receiving potash alone and with nitrogen, was again good and though there was a considerable amount of leaf scorch this trouble was probably accentuated by the very dry and hot summer. The reduction in amount of scorch effected by the potash was shown by the fact that scorch was much more severe on the "no potash" plots. As, however, the trees of Bramley's Seedling have had only one "bearing" year during this period the trial is being continued for another season to obtain further data on the effect on crop.

(ii) *The treatment of trees in grass.*—On one plot, consisting of Bramley's Seedling and Worcester Pearmain interplanted at 15 feet square, grass had been sown in the spring of 1930, and with the exception of 1½ cwt. per acre of sulphate of ammonia in July of that year the plantation had received no nitrogenous manuring from that time to the late winter of 1932-33, when the first dressing of Nitro-chalk was given. Symptoms of nitrogen starvation were very marked.

On the second plot, from which the interplanted trees of Worcester Pearmain had just been grubbed, the lack of nitrogen was not yet acute as the grass had been sown only a year before. The aim was therefore to prevent the starving effect of the grass and consequently the 5 cwt. per acre of Nitro-chalk was applied to the Bramley's Seedling, comparable trees being left unmanured.

The results in the case of Worcester Pearmain were very definite. The difference in fruit colour was very striking, while there were also marked contrasts in firmness of fruit and condition of foliage. With Bramley's Seedling also there were distinct differences in leaf colour, while the fruit from the unmanured plots had a much more mature appearance than that from those receiving the Nitro-chalk.

(iii) *The manuring of young trees from planting.*—As in the previous year leaf scorch was severe on the plots which had received no potash. Where the comparatively small annual dressing of 2 cwt. per acre had been given since planting growth was very good and leaf scorch of little importance.

Plums.—The pot culture experiment with the variety Victoria has been continued. There has been a marked response on the part of the trees to certain of the treatments, and the results so far obtained are in accordance with those previously recorded with other fruits and with hops. So far it has not been possible to obtain any infection as the result of spraying the leaves with a suspension of the " die back " bacteria. This method of infection will be tried again during the coming season, and should it not prove successful stem inoculations will be given in the Autumn.

(i) *Variety collections and trials.*

Observations made on the collection of apple varieties have been continued. Those varieties which appear worthy of retention are being transferred to the cordon variety plot.

(j) *Fruit breeding.*

Rootstocks.—The work in connection with the raising of new varieties of apple rootstocks combining immunity to attack by woolly aphis with the desirable characteristics associated with good rootstocks, being carried out jointly by the John Innes Horticultural Institution and the East Malling Station, has been continued. During the past season 500 seedlings consisting of back and intercrosses between immune seedlings were raised at Merton and 500 seedlings consisting of crosses between Northern Spy and Paradise and Selected Crab rootstocks were raised at East Malling and passed over to the Entomological section for artificial inoculation. A further series of crosses between Northern Spy, Winter Majetin, Transparent de Croncels, Reinette Zuccamaglia and Ben Davis were made. Such crosses between two immune parents will probably give rise to a higher percentage of immune seedlings, whilst seedlings from these crosses may in some cases prove to be new immune scion varieties of value, as well as rootstocks. Measurements of wood growth, girth of stem and counts of blossoms and fruit on one series of immune rootstocks, multiplied in quantity and worked with Lane's Prince Albert were made during the year.

The crossing together of members of the Malling series of " Paradise " apple rootstocks with the object of evolving new rootstocks of economic value has been continued. The series of apple rootstock crosses, raised in 1929, now in their second year as stools, have given a further crop this year. They will be subjected to a careful examination and selections for further trial will be made. A paper (4) dealing with observations, extending over several years, on the inheritance of root and shoot characters in these seedlings was published during the past year. It was found that most of the characters studied were not of a sharply discontinuous nature, owing, it is thought, to the polyploid chromosome constitution of the apple. The observations were originally made in the hope that it would be possible to correlate certain easily distinguishable characters in the young seedlings with the later performance of the seedlings as rootstocks, thus making it possible to shorten considerably the period during which it is necessary to test them. Unfortunately the observations on the inheritance of characters in these seedlings make it seem extremely unlikely that this will ever be practicable.

Measurements of wood growth and girth of stem and counts of blossoms and fruits were again made on a series of selected seedlings of a cross between Nos. VIII and IX, raised at Merton in 1924, and worked in quantity with Lane's Prince Albert. Interesting differences in vigour and precocity are already appearing in these trees.

A large number of crosses between varieties of plum rootstocks were made with the object of producing new varieties of plum rootstocks more easily propagated by the methods at present in common use and showing a wider range of influence over the scion variety. Of all the crosses made the most compatible were those between Pershore and Brussels, and Common Plum and Brompton, while the diploid Myrobalan seedlings failed completely when intercrossed. Taking all the crosses together, of 2,442 flowers pollinated, 212 fruits, or 8·6 per cent., matured. It will thus be seen that progress in raising these plum rootstock seedlings must necessarily be slow.

Scion varieties and the shortening of the " juvenile period ".— Several families of seedlings designed to produce new varieties of outstanding quality or extended season have been raised. The programme of crosses designed to shed light on the inheritance of fruit colour in the apple has been proceeded with. Observations have been continued on the series of seedling crosses worked on Rootstocks Nos. IX, II and XII and planted out as cordons during the winter of 1931, to test the influence of rootstocks in hastening the blossoming of seedling apples. The effect of differential methods of pruning is also being tried out. The grafts of apple seedlings worked on to a seventeen year old tree of Lane's Prince Albert during the spring of 1932, to see how far this method would

induce earlier fruiting in the seedlings, have continued to make vigorous growth throughout the season. About one hundred seedlings, now in their third year, being grown in pots to see how far the restriction of their roots will induce earlier fruiting, half of which have been kept under glass and half in the open air, have not so far shown any sign of blossoming. Already, however, the series under glass are showing a marked increase in vigour over those left in the open air.

A number of apple and pear seedlings, raised in 1930, and growing on their own roots, were planted out as cordons in their permanent fruiting quarters during the past winter together with a batch of apple and pear seedlings raised from seed sent from Russia which are being fruited to see how far they will prove of use as new varieties.

A number of pear seedlings from crosses designed to produce new varieties of high quality were raised during the past year.

(k) *Pomological aspects of spraying.*

Arising out of the fungicide trials, the incidence of spray-damage continues to be observed in connection with factors such as root-stock, manuring, weather conditions and cropping. At present a general statement on the influence of these factors would not be justified. With regard to the repeated damage formerly caused on Cox's Orange Pippin by Bordeaux mixture at " full " strength (i.e., containing 8 lb. copper sulphate per 100 gal.), it can now be stated that as with lime sulphur, reduction in strength of Bordeaux mixture leads to greater safety on the tree, while the relationship between spray injury and fungicidal efficiency appears to be in direct proportion.

A field trial was started in 1933 to test the possibility of reducing lime-sulphur injury by the use of ferrous sulphate in the spray.

(l) *Marketing problems.*

The influence of such factors as variety, stock, pruning, thinning, cultural and manurial conditions, as heretofore, is being carefully watched in relation to market value over a period of years.

(m) *Kent fruit soils survey.*

The joint survey of the Lower Greensand area in Kent has been prepared for publication in bulletin form.

The survey of the Hastings Beds area in Kent has been completed in conjunction with Wye College, and the joint report is in course of compilation. Two points of special interest in this survey are the close correlation that has been observed between tree performance and soil series and the many variations to be found in soil series within comparatively close topographical limits.

One soil series in particular was found to be associated with marked vegetative vigour in all fruits. Owing to the localised distribution of the soil series however, it would clearly be impossible without further survey to forecast with any degree of accuracy how much of this desirable kind of soil there may be still available for planting in the parts of the Hastings Beds still unsurveyed. Of the top fruit surveyed roughly one half consisted of trees of bearing age, the remainder being divided almost equally between trees under 10 years and trees already past their prime. As between grass orchard and plantation management the top fruits were found to be grouped roughly in the ratio of 2 to 1, approximately 1,000 acres being in grass and 500 under some degree of cultivation. With regard to the distribution of mixtures of top fruit, about 60 per cent. was found to consist of apples interplanted with plums and 10 per cent. contained admixtures of other kinds of fruit in addition to apples and plums.

(n) *Walnuts.*

Propagation.—Clonal rootstocks, for the purpose of grafting with good named varieties, are being raised by the layering method. In 1933 all the layers were treated with a mixture of "spent" hops and sand in the first two earthings, as freer rooting was found to result when this method was used in 1932. On opening up the stools, rooting of the layers was found to be better than in past years, satisfactory rooting being recorded for the first time on some selections of *J. nigra*. Slight rooting was also found for the first time on layers of named varieties of *J. regia*, indicating that there is reason to expect better rooting as the stools become older and the vigour of the annual shoots is reduced. 235 rooted layers have been cut off and planted in nursery rows preparatory to grafting with named *Regia* varieties. These layers consist of representatives of Royal and Paradox hybrids, *J. regia*, *J. nigra*, *J. sieboldiana*, *J. Cinerea* and *J. mandschurica*.

In 1933, 320 grafted plants of twelve varieties that have been chosen as most suitable for growing in this country were raised under glass. These include a small trial in which pieces of root from established trees were used as stocks, thus showing the possibility of this method for the production of clonal rootstocks.

In the summer of 1933 another budding programme was carried out in the open. In 1932, August was found to be the optimum time for budding, and in 1933 buds were put on chiefly in this month. In previous years the stocks have shown a good callus, therefore an attempt was made in 1933 to alter the physiology of the buds by ringing the shoots above or below the buds for use, at various intervals before budding. Other shoots were beheaded before the buds were used. It is hoped that some such method may result in a reliable budding technique.

Pruning experiments are being carried out with a view to the production of bush walnut trees for quick cropping in a restricted

space. Trees that were lightly pruned in the spring of 1932 developed short stubby shoots during the summer; these, in some cases, are bearing buds which will grow out into catkins and fruit buds respectively in 1934.

Varieties.—The dates of leafing out of trees in the nursery and in the variety collection were again recorded. In addition, varieties injured by the late spring frosts of 1933 were recorded at the Research Station and on the six experimental sets of trees which were planted in different localities at the end of 1931. The importance of the late-leafing habit of the twelve varieties selected for rapid propagation was thus confirmed.

Records were taken on the growth and vigour of the experimental sets of trees, during the late summer, and on the incidence of diseases. As these trees are now becoming established, interesting differences are becoming apparent between the same varieties in different localities.

A detailed classification of walnut varieties has been commenced, with a view to drawing up a table by which the better-known varieties may be identified from their vegetative characters.

The nutlets on older trees were again hand-pollinated where catkins had not appeared, and notes were made of the dimensions sealing, flavour, etc., of the resulting nuts.

Oil content determination.—The percentages of oil and moisture were determined in samples of fresh nuts from the trees selected at the Walnut Competition in 1929. It was generally found that the good quality is being maintained, and that a slightly higher oil content was reached than after the wet summer of 1931.

Curing and storage trials.—An average sample from a local tree was used in these experiments. After removing the green, outer husks and washing the nuts, a portion of them was dried in the furnace room at 90° F. to constant weight.

The dried and fresh nuts were then bleached, a portion being left untreated in each case.

Several attempts were made to counteract the effect of moisture absorbed by impurities in common salt when used as a storage medium. This trouble was largely overcome by mixing the salt with sodium phosphate or with coco-nut fibre refuse, both of which counteract the deliquescent properties of the salt.

Samples of fresh and dried nuts were dipped in paraffin wax before storing. This method has now been abandoned owing to deterioration in flavour of nuts so treated, after a few months.

All nuts were stored under cellar conditions in the winter of 1932. Hitherto suitable apparatus for drying the nuts successfully has not been available. In the coming season this problem of eliminating moisture from walnuts before they are stored will receive special attention.

In Relation to the Small Fruits.

(a) *Nomenclature, classification and variety trials.*

A fresh planting of the four main groups of black currants has been made in order to maintain the continuity of crop records and meteorological conditions which have been kept since 1916. Various distances for planting different varieties are being tested, and this is also being tried out in a comparison with the New Seedling, Wellington's Triple X and Baldwin.

The trial of clonal races of the principal varieties of classified red currants (in randomised blocks) yielded its first crop during the season.

The classification of the mixed material grown under the group name of " loganberry " has been continued. A number of visits has been made to commercial plantations, and has confirmed the opinion that the loganberry is not a clone and is also often mixed with the phenomenal berry. A progress report which has been published during the year (16) contains a description of the loganberry and phenomenal berry in addition to notes on propagation, transplanting, training and susceptibility to disease (17).

(b) *Propagation and establishment of clonal races.*

The propagation of clonal raspberries has reached a further stage with the establishment of a Lloyd George nursery consisting entirely of clone material. Canes sent out in the autumn of 1934 in small lots for the planting of cane nurseries will be taken from this plot.

Satisfactory progress has been made in the establishment of a virus-free clonal race of Royal Sovereign, in collaboration with the pathological section.

Individual plant records of vigour, health and cropping have been taken on the 800 two year old clonal strawberry plants whose whole life history from the time of their formation has been recorded. Though in the first year the earliest formed runners had the most blossom, very little difference in cropping in the second year was found between plants of early and late origin, and between primary, secondary and lateral runners. The late formed runners, originally much smaller, had at the end of two seasons approximated in size to the larger earlier formed runners.

A new runner bed was planted to test methods of raising virus-free material.

All plants planted in 1933 were hot water treated to eliminate insect pests, and every care is being taken to keep out disease by spraying and by removing diseased plants.

Several strains of Royal Sovereign have been collected for comparison, and clonal races of several other varieties have been started.

Clonal stool beds of a number of blackberries, dewberries and loganberries have been planted. Experiments with regard to methods of propagation and transplanting are being continued and extended.

(c) *Planting, training, pruning, etc.*

The first series of " strain," time of planting and de-blossoming experiments have reached their conclusion and the six years' records are now under review. The last year's crops were much reduced by the incidence of the " yellow edge " virus. The importance of this trouble is illustrated by crop records of a small number of comparable plants half of which were healthy both in 1932 and 1933 and half of which appeared healthy in 1932 but showed " yellow edge " in June, 1933. The crop was about one-third less on the " yellow edge " plants than on the healthy plants.

The loganberry spraying and training trial is yielding useful information as to the comparative value of the four training methods, in limiting the spread of the spores of the cane-spot fungus from the old to the new cane.

(d) *Manuring.*

The manurial trial of Lloyd George raspberries was concluded this year.

During these last two seasons since a report was published the earlier conclusions were further established. The most interesting additional information has been with regard to Kainit. While in no year can it be said that Sulphate of Potash has harmed the crop, Kainit, when applied in March, has proved definitely detrimental to crop on two occasions—1929 and 1933, both of which were exceptionally dry seasons. In other more normal years the time factor has not been significant, or as in 1931, when a wet April followed a very dry March, the late application in March gave a better result than that given in December. It seems likely therefore that the use of Kainit on raspberries is inadvisable, since though it may do good in a wet year, in a dry year it may do definite harm, especially if applied as late as March.

(e) *Fruit breeding.*

Black currants.—An acre plantation of seedlings now in their sixth and seventh years, raised from crosses between the best selections from previous seedling families and the main varieties gave their second appreciable crop during the past summer. Careful records were again made upon the fruiting characters and a number of further selections were made.

About one thousand seedlings consisting of crosses between the main varieties, now three years old, fruited for the first time during the past season. The vegetative and fruiting characters of these

seedlings were again recorded together with those of a number of self pollinated families of the same varieties and an analysis of the records indicates that many of the characters of the black currant are apparently inherited in the manner usual to simple diploid plants.

A large number of seedlings have been raised from the seed of Baldwin and Boskoop Giant and of crosses between them, subjected to X Rays, and from seed produced from irradiated ovules and pollen. The treatments were applied during the spring of 1932, at the John Innes Horticultural Institution. Germination was very variable and, so far, there is no evidence that the treatments have altered any of the morphological characters of the seedlings.

Records of the crop on the large scale trial of Wellington's seedlings were again made and satisfactory crops were obtained. These three selections and particularly " Triple X " continue to be in demand among small fruit growers.

A batch of three year old seedlings from crosses between the black currant and the gooseberry and the black currant and *Ribes longeracemosum* flowered for the first time last spring. Unfortunately in no case did the flowers mature fruits.

Red currants.—A number of families of the red currant seedlings, now seven years old, obtained by selfing the main varieties, gave their first considerable crop during the past season. A number of the seedlings were of outstanding promise and will be closely watched during the next few seasons.

A number of fresh *Ribes* species have been added to the Station's collection during the past season and descriptions of the botanical characters of the species are being continued.

Strawberries.—Observations were made during the past season on two families of seedlings from crosses between Royal Sovereign, Sir Joseph Paxton and Lefebre. They again showed striking differences in their susceptibility to " yellow edge " disease. Material has been prepared from certain of the seedlings and further crosses will be made during the coming reason to determine how far susceptibility to the disease may be a question of genetic factors.

(f) *Fruit Thinning.*

Gooseberries.—The experiments detailed in the last report have been continued.

(g) *Statistics and Records.*

At the end of its sixth year, the Statistical Section finds itself very fully occupied in catering for the needs of other research workers, not only in other sections at this Station, but in increasing numbers from other Institutions.

Plot layout.—During the past season, owing to the rapidly decreasing amount of ground available, the number of major experiments planned has been small. Nevertheless, while the older trials continue to justify the great care which was taken in their preparation, a number of smaller trials, particularly in the nurseries, have been projected. A rather new departure has been the utilisation of older experiments for new projects. The planning of some of these has been of necessity rather crude, since the original trials were not designed for this purpose; and the fact that individual tree records of growth and cropping have been kept on the trees since they were planted, alone makes such trials possible.

During the past year six trials have been planned for institutions overseas, and two at home. Apart from these several research workers have visited the Section in order to discuss their particular problems of plot arrangement and recording, while five have spent varying periods here studying modern methods of plot layout and analysis.

The experience gained by this outside work has been of great interest and mutual benefit.

Records.—A feature of the past season has been the large number of reports issued by the Pomology Section. This has entailed the preparation of summaries and tabled results of many of the major experiments, in particular the rootstock trials, over a period of some fifteen years.

During the year a new uniformity trial of strawberries using clonal material has been planted.

Records of size and cropping of individual plants are being taken and it is expected that this trial will form the basis for future strawberry experiments here.

Technique of recording.—A considerable body of data with respect to the relationship between the various measures of vigour and cropping of apples trees have now been collected; and it is hoped to produce a report in the near future.

PHYSIOLOGY.

Vegetative propagation.

(a) *Cuttings.*—The promising results obtained from increasing the moisture supply in the rooting medium and at the same time reducing water loss by shading are being followed up by an extended experiment. Further intensive trials are being made to analyse the influence of time and depth of planting, etiolation planting medium and leaf fall on rooting of stem cuttings.

(b) *Layers.*—Detailed records have been taken at short intervals throughout the summer of the growth of layer shoots of plums in the search for the factors producing wide differences of rooting of apparently similar shoots.

A census has been taken and will be repeated of individual layer shoots to determine the influence of size, thickness, position and etiolation on subsequent root production.

Leaf relations in apple trees.

The distribution of leaf surface.—The results of the investigation, carried out in 1931 and described last year, of the leaf relations of two nine year old apples trees, have now been published. (39).

A sampling method for determining leaf relations in large trees was worked out during the summer and tested on some 16 year old trees of Bramley's Seedling on two stocks and under two manurial treatments. It was found that the method is sufficiently sensitive to show comparatively small differences between trees.

Another method for estimating the effect of experimental factors, such as rootstock and manurial treatment, upon the amount, time and character of shoot growth has been tested out on 64 four year old trees of Cox on the new manurial plot and has given satisfactory results.

Carbohydrate relations.

A technique has been evolved for the determination of starch and some sugars in apple leaves, and is being applied to samples of spur leaves taken at intervals throughout the 24 hours from trees of Lane's Prince Albert on very dwarfing and on very vigorous stocks, in order to determine whether the diurnal cycle of changes of carbohydrate content is different in the two cases.

Growth.

Seasonal course of root and shoot development.—The data obtained in the investigation carried out on the unworked apple stock No. XIII are being analysed and prepared for publication. The results already obtained justify the extension of the investigation to worked trees. Maiden trees of two different apple scion varieties, each on four different stocks, are accordingly being planted out this winter and will be lifted in the form of six successive samples during the course of the growing season in 1934. The trees in each sample will be submitted to a morphological analysis to determine the effect of scion variety and of rootstock upon the rates of growth of roots, stems and leaves at different times of the year.

Effect of scion on root.—The trees of the apple varieties Beauty of Bath and Grenadier that have been prepared for an investigation into the causes of the marked difference in amount of root growth in trees of these two scion varieties, were planted out last winter. They will be ready for lifting and for morphological analysis next summer.

Size of tree in relation to other measurements.

The records of a large series of trees of Grenadier on VI have given full confirmation of the indication formerly obtained that "percentage fibre" in a root system decreases with increasing size of the system as a whole, other factors being equal. The proportion of stem was constant throughout a wide range of tree size and the ratio of weight of scion to cross sectional area of main stem increased with the weight of the tree.

Pruning.

The response of several series of trees, comprising many combinations of stock and scion, to different degrees of winter pruning has been determined by morphological analysis and a report is being published. New shoot growth and total new stem growth are progressively reduced by progressively more severe pruning, but a redistribution of stem growth is effected. Pruned trees although showing less total stem increase than unpruned trees dispose of a larger proportion of their stem growth in the formation of new shoots and a smaller proportion in the thickening of existing stems. The proportion of new stem growth to new root growth is unaltered by pruning.

BIOCHEMISTRY.

Mutual influence of rootstock and scion.

Ash analysis.—A quantitative spectrographic method, applicable to the majority of the mineral elements occurring in fruit trees, has been found. This method, however, is not applicable to molybdenum, an element of peculiar interest, titanium, vanadium, etc.; but it is hoped that the difficulties presented by these elements are nearly overcome and that shortly a method now being devised will be applicable to all the mineral elements.

Functions of the elementary constituents (tree injection).

(a) *Distribution.*—Further work on tree injection has led to simple rules for producing at will the types of distribution required for experimental work and for commercial application, i.e., permeation of a whole tree (roots and top); permeation of single branches, and the roots in direct connection with them, each with a different substance; permeation of twigs or branches each with a different substance without any of the substance getting into the roots.

These rules are based mainly on the vascular anatomy of the tree, but some consideration must be given to changes in the suction relations inside the tree resulting from the opening of the tissues to let in the injected solution.

Methods have been devised for avoiding certain pitfalls in the practical application of these rules.

(b) *Avoidance of damage.*—In collaboration with the Council for Scientific and Industrial Research, Australia, about 1,000 young apple trees were injected with the common artificial manures, both singly and in mixture. The main purpose of this work was to determine how far it is possible to avoid the damage which sometimes results from injecting even common artificial manures. The damage produced by all the artificial manures tried was similar to the type of leaf scorch associated with potash deficiency. The amount of damage may be reduced to nil either by reducing the total amount of substance injected or by increasing the volume of water in which it is dissolved.

Enough of any soluble artificial manure may be injected in two days in summer to produce as great an increase in growth and vigour as that produced by the heaviest dressing ever applied to the soil; and this can be done without causing any damage to the tree.

Enough manure to produce a marked increased growth may also be injected without damage in the winter, but the maximum safe amount is less in winter than in summer.

The toxicity of a given quantity of nitrate is less when in the form of a 4 : 1 mixture of potassium and calcium nitrates than if present as either of the pure salts; and the antagonistic ratios of these and other salts are approximately the same as those obtained by more usual methods.

The most convenient injection method is to drill one or sometimes two holes $\frac{1}{4}$ inch or less in diameter through the main stem or branch. Such a hole heals over in one season and there has been no evidence of such holes causing the tree any damage.

(c) *Results of injection.*—The experiments were not designed primarily to demonstrate any beneficial effects of injection; but one such effect was established; a 25 per cent. increase in shoot extension growth resulted from injecting a mixture of potassium sulphate and ammonium phosphate.

Other results also point to the injection of single salts being beneficial; and the experiment as a whole has yielded data on the basis of which an experiment is being planned for next season to assess the beneficial results obtainable by injection of artificial manures.

PLANT PATHOLOGY.

Mycology and Bacteriology.

Crown gall.—The experiments carried out to test the effect of applications of sodium nitrate to apple trees artificially inoculated with the crown gall organism (*Bacterium tumefaciens*) have been continued; the results will not be fully manifest until the end of another season's growth.

Galls on various host plants have been examined (i.e., loganberry, dahlia, mangold, vegetable marrow) and organisms have been isolated; these organisms are being compared with others previously isolated from crown galls with a view to studying their relation to crown gall on fruit trees and bush fruits.

Brown rot diseases.

Experiments have been continued for investigating the manner of leaf infection by *Sclerotinia cinerea* in relation to the wilting of plum stocks in the layered nursery rows. Infection resulting in the wilting of the shoots was induced not only by inoculating punctured leaves but also, in some cases, wilting appeared on shoots bearing leaves which had been inoculated without wounding.

Observations with special reference to recent severe outbreaks of Blossom Wilt have been recorded (21, 30) and a further note on the infection of apples through the wound made on picking the fruit without stalks has been published.

Bacterial diseases of fruit trees.

Bacterial canker of plum trees.—The morphological and physiological characters of the organism causing Plum Bacterial Canker have been studied in detail (24). The organism shows certain cultural characters which distinguish it from *Pseudomonas prunicola* (previously described as causing a bacterial shoot wilt of plum trees) and the name *Ps. mors-prunorum* has been given to the bacterial canker organism.

The experiments to test the effect of soil conditions on the predisposition of trees to bacterial canker are being continued.

Bacteriosis of cheery trees.—The physiological tests are being extended to organisms isolated from lesions on leaves, branches and stems of cherry trees in order to determine what relation these organisms bear to the two species that are pathogenic to plum trees.

Spraying trials.—Trials have been made testing Bordeaux mixture and zinc-lime on plum and cherry trees during summer. No bacterial spotting appeared on any of the trees so the bactericidal properties of these sprays could not be determined. The Bordeaux mixture proved to be more injurious to the foliage than the zinc-lime. It seems possible that zinc-lime (a spray fluid recommended in America for use against bacterial spot of peaches) may prove more useful, for bacterial leafspot in plums and cherries, than Bordeaux mixture especially as its active ingredient, zinc sulphate, has proved, in laboratory tests, to be more toxic than copper sulphate to cultures of *Ps. mors-prunorum.*

Raspberry mosaic disease.

(i) *Analysis of symptoms and varietal susceptibility.*—A description of raspberry mosaic as found in Britain has been published (27). It is shown that there are three main symptom types, (*a*) mottling evenly distributed over the leaf with no distortion or curling of the lamina, (*b*) chlorotic patches ill-defined, accompanied by a symmetrical down-curling of the leaf : symptoms masked by high summer temperatures, and (*c*) chlorotic patches sharply defined, not masked by summer temperatures. Varieties of raspberries differ in the rate of increase in the number of stools showing mosaic symptoms and in the relative rate of degeneration of infected stools.

(ii) *Experiments in commercial control.*—The six cane nurseries for the production of mosaic-free canes of *Lloyd George*—one at the Research Station, and five elsewhere in Kent and Sussex—have again been twice rogued; they proved, as in previous years, to have a minute proportion of plants infected with mosaic. The demand for canes has been quite equal to the increased production, amounting this year to at least 60,000 canes in all. Almost the whole product of the parent nursery at East Malling has again been distributed for the planting of further cane nurseries; thus nuclei of mosaic-free material are now becoming fairly wide spread.

Loganberry cane spot.

This year the main spraying trial was planned with a view to determining the relative efficiency of Bordeaux mixture and lime-sulphur applied immediately before the flowers opened. Observations showed that Bordeaux mixture (6—9—100, made with hydrated lime) gave a better control than lime-sulphur.

Observations made during the summer on the life-history of the fungus go to show that a fungicide incorporated with the second application of derris against loganberry beetle would be too late to check cane spot.

This summer (1933) the fungus has been recorded on loganberry fruit.

Cane spot records have again been taken on the trial plot of loganberries in which various methods of training are being tried out.

Strawberry diseases.

The "yellow-edge" disease.—A full report of this disease has been published (28). Grafting experiments are described which demonstrate the existence in this country of a virus disease of the strawberry. The principal symptoms (studied chiefly on the Royal Sovereign variety) are a general dwarfing of the youngest leaves accompanied by a yellowing of the marginal region and a curling and distortion of the leaflets. The petioles are short, stout and lacking in the normal red pigmentation. This disease, for which

the name " yellow-edge " is proposed, shows symptoms that bear a close resemblance to those of strawberry Xanthosis as known in America. Control measures are directed towards the elimination of virus-infected runners from the runner beds.

Root rot of strawberries.

The investigation of this disease was started this past June. Although results to date are exceedingly meagre nevertheless evidence has been obtained which points out that this trouble may be of considerable importance in connection with the general degeneration of strawberries. Several plantations have been found affected with this disease, which takes the form of a rotting of the roots of affected plants. A short note concerning this trouble was published in Nature.

The above ground symptoms are a dwarfing of the leaves and petioles resulting in a flat type of growth, but with no yellowing or distortion of the foliage as in the case with mite, aphid or virus attack. Such above ground symptoms are however to be considered merely as an indicator of the disease, because definite diagnostic symptoms are to be found only on the roots. The root system of affected plants is very poor, many of the roots being dead, and many others showing definite black lesions on an otherwise healthy root. The lack of fibrous root is pronounced. This state of the root system is brought about by parasitic soil fungi. So far a species of *Coniothyrium* isolated from diseased roots has consistently produced the disease on healthy clone plants growing in sterilized soil.

" Fruit-russeting " and " branch-blister " disease.

The part of this problem concerning growth of the associated fungus in pure culture, and subsequent inoculation experiments, has had to remain in abeyance during the past year, for the work requires much time that cannot at present be spared for it. Further examples of the occurrence of the disease in commercial practice have been observed during the year, and they served to confirm the opinion, stated in the last report, that the association of a fungus with the typical symptoms is likely to be secondary in importance to the influence of as yet undetermined environmental factors. The plot of young trees under different manurial treatments doubtless will, in time, afford a profitable medium for observations designed to find possible correlations between the occurrence of disease symptoms and the manurial treatments.

Fungicide trials.

Apple scab and apple mildew.—The second year's data obtained from a re-planned spraying and dusting trial has now been

classified, and conclusions drawn in last year's report are substantiated. Certain observations made in the same trial on the incidental control of apple fruit sawfly, red spider and brown rot, by treatment designed for control of apple scab and apple mildew, have been published (22).

During 1933, it was decided to experiment extensively rather than intensively, using much of the information gained in intensive trials in an attempt to determine the best minimum spray-treatment for controlling scab, apple fruit sawfly and various caterpillars in a Cox plantation.

Pear scab.—The results of two years' work (1931 and 1932) on the control of this disease have been published as a complete experiment (23).

" Spreader " trial.

A field trial of different " wetters " and " spreaders " has been in progress for the past two years in collaboration with Wye College.

Factors affecting susceptibility to apple scab and mildew.

Further data on the effect of rootstock and manuring on susceptibility to scab in Bramley's Seedling and Worcester Pearmain were obtained during the year.

Apple canker.

Records on the infection by canker of Cox's Orange Pippin worked on different rootstocks have been collected for several years on the trees on the spraying trial plot.

Diseases of walnuts.

Walnut bacterial blight.—To control walnut blight, stem lesions were cut out of all trees in the nursery and in the variety collection before the trees leafed out in spring. The bacteria which cause blight have, however, been isolated from bud-scales during the winter, as well as from stem lesions, therefore the disease cannot entirely be overcome by cutting out the lesions. This being so, three applications of Bordeaux mixture were given to the nursery trees during the spring and summer, a few unsprayed trees being left as controls. Owing to wet weather shortly after the trees leafed out, blight spread early on the unsprayed trees, so that, in the autumn, more infections were recorded on these trees than on those that had been sprayed. As a result of the hot dry summer very few late infections occurred and three spray applications gave good control of this disease.

A disease following grafting.—Work has been continued on the fungus *Chalaropsis thielavioides*, which has been found to

infect nursery walnut trees. Its morphology and cultural characteristics are being compared with those of similar fungi isolated from carrots and from peach seedlings. These fungi are also being compared with *Thielaviopsis paradoxa*, a nearly related fungus.

Further experiments have been carried out to test the parasitism of *Chalaropsis* on other hosts, in order to determine the extent of its importance in this country.

Further investigations into methods of controlling the disease on walnut grafts have proved the efficiency of fumigation of the greenhouse by formalin, as an alternative to wet spraying.

Other diseases.

Pear bacterial blossom wilt.—Severe blossom wilt occurred on bush and cordon pear trees on the Station. The diseased tissues contained bacteria. Several strains of bacteria were isolated from the lesions, and they were tested for their pathogenicity; as flowers were not available by the time the organisms were isolated inoculations were made on young pear fruits. Four of the strains induced lesions on the fruit so these have been retained for further study.

Entomology.

The control of the fruit tree red spider.

Experiments in relation to the control of the fruit tree red spider have not been continued this year, but further detailed records have been made upon the life-cycle of the mite under natural conditions. The winter egg laying period proved to be much earlier than usual, the oviposition period commencing in the middle of August and continuing until October. Many of the winter eggs were observed to hatch in September. Under normal circumstances the fruit tree red spider hibernates on the spurs of the trees in the form of a winter egg; the eggs not hatching until the spring.

Resistance of rootstocks to woolly aphis attack.

During the year, 961 seedlings have been tested for immunity. Of these, 504 were raised by the John Innes Horticultural Institution, and were crosses of Northern Spy with immune seedlings Nos. 789 and 793. Of these 245 proved to be immune, the percentage of immunity of the different families ranging from 44 per cent. to 55 per cent.

392 seedlings found immune last year were tested again and 293 remained immune.

A number of check trees of N. Spy, Seedling 789 and Seedling 793 which were kept in the house and inoculated with the others remained immune throughout the season.

A number of immune seedlings tested at East Malling have been sent to India, Canada, South Africa, New Zealand, Australia,

Argentine and Morocco to be tested for resistance to woolly aphis under the climatic conditions obtaining in those countries.

Causes of immunity.—The investigations into the causes of immunity have been continued this year and progress has been made with the method of feeding the aphides on media prepared artificially from the bark of susceptible and immune varieties of apple. Media prepared by several methods from different chemical fractions of the bark have been compared in a series of trials and between some of these it has been found possible to obtain a difference in length of life of nymphs similar to that existing between the living trees. This suggests that the substance which confers susceptibility is extracted unchanged from the bark. Results have tended to confirm the previous inference that immunity is due to chemical causes and that a solution of the problem may eventually be reached along these lines.

Woolly aphis parasite.—Weather conditions have been favourable for the spread of *Aphelinus mali* and in one orchard at East Malling where it was liberated in March, 1933, it has spread through the infected block of trees and parasitized aphids have been found at a distance of 144 yards from the point of release. The parasite, however, ceased to be active before the Woolly Aphis and winter colonies of aphis appeared on previously uninfected trees during October.

Apple sawfly.

Extensive field spraying and dusting trials were carried out together with observations on the life history of the pest in order to determine which are the most vulnerable stages. The following were tested: derris (in both wet and dry form), nicotine, lead arsenate, barium silicofluoride and a special combination of nicotine with a wetter and spreader.

A progress report has been prepared for publication which throws new light on such points as the vulnerability of the egg and larval stages and the value of a derris dust as a means of preventing oviposition.

Apple blossom weevil.

Tests of derris dust as a means of preventing oviposition were made and have been described in a progress report. Some of the tests were of sufficient promise to justify further trials of derris.

Experiments were continued to determine whether the weevils can be induced to shelter in chemically treated corrugated cardboard bands, which will in time destroy the weevils. The destruction caused to the bands by birds and mice has also been noted, and some of the treatments tend to keep both birds and mice away.

The apple fruit tortricids.

Detailed investigations have been made upon a number of tortricids which infest fruit trees and also feed upon the maturing apples, etc. Some 400 specimens of moths have been reared and great variety of species have been noted. Of these two or three species prove to be more abundant than the rest.

The life-cycle of the important species is being worked out.

The effect of certain gasses upon the larvae of these moths, under gas store conditions, is also being studied.

Systematic study of gall mites.

A systematic study of gall mites which infest plants is being continued, and considerable trouble has been experienced in identifying species on account of the difficulty of preserving them in a satisfactory manner.

During the year one new species has been described (36).

Tarsonemid mites.

A collection of the species of mites of the genus *Tarsonemus* which infest cultivated plants is being made.

The strawberry tarsonemid mite.

The strawberry tarsonemid mite has proved to be more serious than in previous years, and more details of its life-cycle have been observed (34).

One aspect of the life-cycle is being studied in particular, namely, the mode of migration. Isolated plants, which were considered free of this mite, have become attacked, and it is thought that the mites may be carried by wind or insects from one plantation to another.

Experiments have been continued to determine whether young plants can be freed of this pest, before planting them out, by sterilising them in warm water for a given period, at a known temperature. Results obtained this year clearly demonstrate that the plants will not only be freed of the strawberry tarsonemid mite, but also from other important pests such as: eelworm, red spider and aphis.

The recommendation suggested is that of sterilizing the plants in warm water at a constant temperature of 110° F., for a period of 20 minutes. After treatment the plants must be cooled off as soon as possible to avoid overheating. A suitable apparatus has been devised for the warm water treatment.

Strawberry "yellow edge" disease.

Investigations are being continued in collaboration with the Mycological Section to determine whether the tarsonemid mite or

the strawberry aphis is a vector of the virus described as " yellow edge " disease. Direct inoculations have been made from mites and aphides from diseased and healthy plants, but so far negative results have been obtained. Virus symptoms have not appeared on a series of plants inoculated some two seasons ago. These investigations are being continued.

Raspberry and loganberry beetle.

Further field trials on raspberries, loganberries and blackberries were carried out with derris sprays of known rotenone content, and a progress report has been prepared. The results confirm those of previous years (32, 33) and demonstrate the adequacy of a single application of a derris spray on raspberries and loganberries and indicate that considerable latitude exists as regards the critical time for applying the spray.

Raspberry shoot moth.

An opportunity occurred of studying this pest (*Lampronia rubiella*, Bjerk) in some detail. Observations were begun on its habits with a view to finding a suitable stage at which derris sprays or dusts might usefully be applied. Experiments on the control of the pest were begun but the preliminary results of these will not be evident before April or May, 1934.

Derris.

The main field tests of the use of derris are referred to above in connection with apple blossom weevil, apple sawfly, raspberry beetle and raspberry shoot moth. Valuable help in connection with the chemical evaluation of the derris used was received from the Rothamsted Experimental Station.

A start has been made with the biological work on the correlation of the toxicity of derris with its various chemical and physical properties.

Phytocidal and insecticidal tests.

Experiments have been started to test the toxic effect of various potential sprays such as barium silico fluoride upon certain insect pests.

In addition the phytocidal effect of these sprays has been tested upon top and soft fruits.

HOPS.

Cultural trials.—The trial of various distances between the hills and the number of bines per string on the seedling L 21 has been continued.

The effect of two distances of planting combined with two degrees of severity in pulling are being studied on the seedling OP 21 (Oregon Cluster × English Male) × English Male.

A trial of three strains of Fuggles is being utilised for a cutting experiment.

Half an acre of the seedling OV 7 (late Bavarian × English Male) will be utilised for investigating the effect of varying severity in pulling and number of bines per string.

A seedling of promise in each of three grades of vigour (weak, medium and very vigorous) is being propagated for use in further cultural trials.

The more extended testing of the best of Prof. Salmon's seedlings is being carried out in combination with the above cultural trials.

Manurial experiments.—An article on the manuring of hops (41) and a bulletin for growers (40) indicating the symptoms that may arise through the deficiency of certain elements of nutrition, have been published.

Distribution of sets.—Sufficient rooted sets of the seedling OP 21 have been raised to enable a grower in the Weald of Kent and another in the West Midland area to each plant up half an acre. This will make it possible to judge the performance of this variety under two very different soil and climatic conditions.

New seedlings.—Seventeen varieties have been grubbed including three commercial varieties, badly affected with " mosaic " disease. Twenty new seedlings have been planted in the place of those grubbed.

The crop from over 200 seedlings was dried separately, and bottle samples for resin analysis taken from 83 varieties. More than 50 varieties were pressed separately in part pockets to enable them to be used for brewing tests.

The analysis of the 1932 crop proved it to be considerably richer than that of 1931. In the early hops × 35 was 1 per cent. higher in preservative value than the sample of Bramling analysed.

Amongst the mid-season hops, nine varieties proved richer than the best commercial variety (Mathon). In the late hops C9a is again top with a preservative value of 14·88 per cent. which is over 3 per cent. higher than the richest American hop (Sonomas). In three previous seasons C9a has beaten the richest American hops by smaller margins. This variety has cropped at an average of 25 cwt. per acre over five years, and is being planted up on a commercial scale by several growers.

No less than thirty-eight varieties proved richer than the Canterbury Golding, amongst which are several of the Manitoba and New Mexican classes, which are very heavy croppers and suitable for " Stouts " with a P.V. equal to American hops.

Amongst the others OP 21 and OV 7 have been used in brewing tests and found satisfactory, the former proving to be a suitable " dry hopper " in a recent trial (42).

Titles of papers issued during the year.

1. *Annual Report.* I. General, 1932. May, 1933.
2. *Annual Report.* II. Supplement., 1932. April, 1933.

POMOLOGY.

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4. Tydeman, H. M.: Breeding experiments with "paradise" apple root stocks. *J. Pomol. and Hort. Sci.*, **11**, 214-236, 1933.
5. Bagenal, N. B.: The planting of apples. *E. Norfolk Fruit Growers' Assoc. Yr. Bk.*, 67-75, 1933.
6. Hatton, R. G., and Bagenal, N. B.: Towards an agricultural policy. Part IV. Section V. Fruit farming. *Country Life*, **73**, 381-383, 1933.
7. Chapelow, H. C.: Apple variety collection. *E. Malling Res. Sta. Ann. Rep.*, 1932, 58-63, May, 1933.
8. Hatton, R. G., and Bagenal, N. B.: Scion rooting at East Malling Research Station. *Kent Farmers' U. J.*, **33**, 226, 1933.
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10. ————: Root studies. III. Pear, gooseberry and black currant root systems under different soil fertility conditions, with some observations on root stock and scion effect in pears. *J. Pomol. and Hort. Sci.*, **11**, 1-18, 1933.
11. Hamond, J. B.: Walnut growing in England—present and future. *Country Life*, **72**, 576-578, 1932.
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13. ————: Some recent investigations into methods of storing walnuts during the winter. *Gard. Chron.*, **94**, 219-220, 1933.
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17. ————: Some notes on loganberries and blackberries. *Kent Cherry and Soft Fruit Show Catalogue*, 17-22, 1933.
18. Garner, R. J.: The use of rubber strips in budding fruit trees. *Gard. Chron.*, **94**, 13-14, 1933.
19. Hatton, R. G.: "Free" or seedling rootstocks in use for pears: Their description, selection, vegetative propagation and preliminary testing. *J. of Pomol and Hort. Sci.*, **11**, 305-333, 1933.

MYCOLOGY AND BACTERIOLOGY.

20. Moore, M. H.: Further studies on the incidence and control of apple scab (*Venturia inaequalis*) and apple mildew (*Podosphaera leucotricha*) at East Malling. *J. Pomol. and Hort. Sci.*, **10**, 271-294, 1932.
21. Wormald, H.: Blossom wilt of fruit trees. *J. Min. Agric.*, **39**, 620-626, 1932.
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24. Wormald, H.: Bacterial diseases of stone-fruit trees in Britain. IV. The organism causing bacterial canker in plum trees. *Trans. Brit. Mycol. Soc.*, **17**, 157-169, 1932.
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26. Harris, R. V., and Grubb, N. H.: The commercial control of raspberry mosaic disease. *Ibid.*, 1932, 149-151, May, 1933.
27. Harris, R. V.: Mosaic disease of the raspberry in Great Britain. I. Symptoms and varietal susceptibility. *J. Pomol. and Hort. Sci.*, **11**, 237-255, 1933.
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30. Wormald, H.: Brown rot fungi: recent observations on their incidence. *Fruit Grower*, **66**, 229-230, 1933, and **66**, 259-260, 1933.

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31. Steer, W.: Two apple capsid spraying trials and some notes on spray damage. *E. Malling Res. Sta. Ann. Rep.*, 1932, 132-140, May, 1933.
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33. ————: Studies on *Byturus tomentosus* Fabr. III. Further experiments on its control on raspberries, loganberries and blackberries. *J. Pomol. and Hort. Sci.*, **11**, 19-38, 1933.
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35. ————: *Tarsonemus approximatus* Banks, *Var. narcissi* Ewing: A variety of tarsonemid new to the British list. *Annals and Mag. of Nat. Hist.*, **11**, 198-201, 1933.
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37. ————: Notes on insect pests and mites in 1932. *E. Malling Res. Sta. Ann. Rep.*, 1932, 109-116, May, 1933.

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HOPS.

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42. Salmon, E. S.: *Sixteenth report on the trial of new varieties of hops*, 1932.

MISCELLANEOUS.

43. Chapelow, H. C., and Tydeman, H. M.: Weather conditions during 1932. *E. Malling Res. Sta. Ann. Rep.*, 1932, 78-80, May, 1933.

15. HORTICULTURAL RESEARCH STATION, CAMBRIDGE UNIVERSITY.

Plant Breeding.

Work has been continued with canning beans, Brussels sprouts, broccoli, cabbage, cauliflowers, onions, parsnips, and strawberries. The policy of co-operation with County authorities and with growers has been continued with results which, on the whole, have been satisfactory.

Canning Beans.—Trials carried out last year showed that a French variety, Comtesse de Chambord, to which reference was made in a previous report, was more suitable to Cambridge conditions than the American and Hungarian stocks with which work was originally begun. The crop of this variety was examined plant by plant and of 151 individuals which produced seed suitable for canning, 53 yielded more than 500 seeds each, the maximum number of ripe seeds yielded by one plant being 886, weighing 172 gr. Two plants were selected from this stock for further work and seed obtained from them was sown in 1933. Examination of the 1933 crop of seed is not yet concluded, but up to the present no significant variation from plant to plant can be found in either of the two cultures.

Information is not yet available concerning the price which canners will pay for a good sample of beans; nor has this vegetable been grown here for a sufficient number of years to warrant its recommendation as a large-scale crop in the Eastern Counties. It can be said definitely, however, that provided the right type of bean is grown, it is possible in a normal year and without any special cultural treatment, to obtain a crop of ripe seeds at Cambridge.

Brussels sprouts.—Trials of Cambridge-bred material were carried out last season at Ixworth and at Dry Drayton. In all, the trials occupied 4 acres of land. A selection of desirable plants from the best stocks was made and these plants were grown on for seed.

Cultures requiring more detailed observation were grown at the Station.

As in previous years, crosses were made and small mass selections seeded under glass.

It is now clear that in future it will be necessary to carry out trials of Brussels sprouts in the area for which it is proposed to breed an improved strain. The Brussels sprout which gives the best results at the Station will not necessarily succeed best in Bedfordshire or in Suffolk. This procedure—trials and selection of plants in the particular area for the benefit of which work is being carried out—is already adopted in the case of broccoli.

Broccoli.—Certain cultures raised from seed of selfed plants of Roscoff type, which had withstood the winter of 1930 at Cambridge, were tested and proved to be as hardy as stocks of " local " Derbyshire broccoli grown side by side with them. The parent plants were, however, derived from stocks bred in Cornwall, and although apparently typical Roscoffs, when selfed showed, with one exception, unmistakeable evidence of a very mixed ancestry. Their progeny was therefore discarded and selection of plants for further work was confined to one culture only.

This season a large number of Cambridge stocks has been planted out at the Research Station and the survivors will be used in the work of breeding a hardy late Roscoff.

Broccoli seed has been distributed to 21 centres in various parts of the country—Hampshire, Kent, Sussex, Cambridgeshire, Derbyshire, Wales, and the Isle of Wight.

Two " local " varieties from Derbyshire were tested last season. These varieties, in leaf type, showed resemblances to " local " Kent strains. Though good, they were not up to the standard of the Kent stocks and were inferior in colour and quality to the best Roscoff strains. They were, however, far superior to any commercial stock of late broccoli tested by the Station.

Cauliflower.—The cauliflower trial was again a failure on account of the drought. The trial of Cambridge material at Kirton was, however, fairly successful and since one of the stocks appears to be suitable for Lincolnshire conditions and can be used either for pickling or for market, a number of selected plants was left *in situ* for seed. The stock in question matures more rapidly than " All the Year Round " (" Driancourt " or " Le Cerf "), and at Kirton in 1932 proved to be more drought-resistant than " Danish Giant ".

Cabbage.—The trial of Red Cabbage held at Denham (Middlesex County Council) contained no stocks which satisfied the picklers' requirements. It was decided, therefore, to ask Messrs. Kearley and Tonge to send specimens of the actual material imported by them from Holland (attempts to obtain seed of the variety used by the Dutch exporters having proved unsuccessful). The heads thus obtained were induced to root in a nutrient solution and were afterwards planted out in the glasshouse. The expected losses from attacks by *Botrytis* sp. and *bacillus carotovorus* took place, but a fair number of plants flowered and from them a good crop of seed was obtained. This, it is hoped, will provide material for breeding the type of red cabbage required by the picklers: a type which, so far as can be ascertained, is no longer procurable in this country.

" Moen's Cabbage ", a ball-headed Norwegian stock sent in for trial by the Ministry, was tested against Sutton's " April " and Boswell's " Offenham " type (a private stock) as a spring cabbage, having been previously tested at the Station as a summer

cabbage. The Norwegian stock all "bolted", but the English types did not.

Work has been continued on the problem of breeding an improved strain of small, early, solid, green-hearted cabbage of the type required by certain growers for the London market.

Onions.—Interest in spring-sown onions and in silver-skins appears to be declining rapidly among market gardeners, on account of the low prices made by this vegetable in recent years. It is not proposed, however, to abandon work with this vegetable. Improved varieties which have been bred at the Station will be maintained in case seed of them may be required at some future date; and certain stocks which have been under observation since 1926 will be utilised for genetic work.

In the trials of silver-skin onions, two varieties were of outstanding value: (1) Sutton's Improved Queen (raised from seed purchased in 1932); and (2) a private stock obtained from a Dutch source. No significant difference could be detected between these two stocks and it is probable that they have a common origin.

Parsnips.—The 1932 crop of parsnips yielded further evidence of canker-resistance in certain cultures raised from single plants. Differences in colour of root was also noted between the various cultures and in one case segregates having very pale skins were present. Canker-resistance and a white skin are desirable characters in commercial parsnips, and although this vegetable is regarded as a side-line, enough work has been done to indicate the possibility of breeding strains having these desirable characters.

Strawberries.—On account of the drought the strawberry crop on the light gravel soil of the Station was a partial failure. Many plants failed to develop their fruits and a large proportion of the fruit produced (this applies to commercial sorts as well as to seedlings) was acid and almost devoid of flavour. Later on in the season a number of plants died. In these circumstances it was difficult to judge the quality of fruit borne by the seedlings; on the other hand, plants and cultures deficient in vigour were automatically eliminated.

Further tests of suitability for canning and jamming were carried out by the Low Temperature Research Station, in the case of a number of seedlings. Plants of seedlings likely to be of commercial value have been sent for trial to Botley (Hants. C.C) and to Rampton (Cambs. C.C.).

Chemistry.

Work on the physico-chemical properties of spray fluids has been continued, and titles of papers published on this subject are appended.

In conjunction with the Station entomologist, further work on attractants for cabbage root fly and for carrot fly has been in progress. The results are now being subjected to analysis.

Experiments on the control of club-root in *Brassicae* and on the effect of soil sterilisation by various chemicals on the seedling growth of *Brassicae* have been made in conjunction with the Station mycologist. Detailed reports on this work are now being written. It has been demonstrated that seedling Brussels Sprouts suffer adversely when sown in soil previously sterilised with the usual sterilising concentrations of mercuric chloride.

Investigations on the keeping quality of onions have been made with the aid of Dr. Barnell, Rockefeller plant physiologist at the School of Agriculture, Cambridge University. It has been shown that keeping quality does not depend on the density of an onion nor on the amount of dry matter contained. Experiments are now in progress which tend to point to the view that the water losses in onions during storage from the actual time of harvest are correlated with keeping quality.

Critical experiments have demonstrated that the inclusion of the protective colloid and emulsifier, gelatin, in spray fluids, does not interfere with the water losses from the foliage.

Mycology.

Most of the 1932-33 mycological work related to club-root of *Brassicae;* much of it was done in collaboration with the Station chemist.

Preliminary experiments were carried out with substances likely to be of use in the chemical treatment of the disease; they were designed to determine the effect of these substances on the growth of brassica plants. In particular the effect of mercuric chloride at various strengths was studied and statistically significant results were obtained.

Numerous experiments were made to determine the optimum conditions for obtaining club-root by the artificial inoculation of plants grown in seed-boxes. By using soil artificially acidified with dilute sulphuric acid and concentrated spore-suspensions prepared from clubs of the current year, regular infections of 90 per cent. and over were finally obtained.

Using this method of ensuring a high degree of infection in the controls, experiments were carried out on the effect of different pH's on the spores of *Plasmodiophora brassicae* and on the toxicity of mercuric chloride to spores kept at two different pH's. It was found that at a strength of 1 in 2,000 mercuric chloride was very much more toxic to spores previously kept at pH 8 than to those previously kept at pH 6.

A field experiment on the chemical control of club-root, in which 18 treatments were tested, was carried out on very heavily infected acid land at Roxton (Beds). The use of a quick acting alkaline substance (potassium carbonate) followed a few weeks later by the application of mercuric chloride or of Ceresan gave the best results both for control of club-root and for plant growth.

It is proposed to test these treatments statistically in 1934, if suitable infected land is available.

Ten varieties of Brussels sprouts, raised at the Station, were tested at Roxton for resistance to club-root. All the plants became infected, but whereas in some varieties the plants were dwarfed and the yield poor, in others the growth and crop-yield were much less seriously affected. These " tolerant " varieties all had in their parentage the strain (26 H) which had shown similar qualities in the 1931 trials.

An experiment on the longevity of the spores of *P. brassicae* in acid soil and in soils made alkaline by the application of lime and potassium carbonate is also in progress at Roxton.

Work on the Wilt disease of strawberries, attributed to *Verticillium sp.*, was continued, but no certain proof of the pathogenicity of the fungus was obtained, although it was again frequently isolated from wilted plants. In a field trial (near King's Lynn) with partial soil sterilisers and artificial manures, treatment with nitrogen gave the best results, but the infection even on the control plots was slight and the results cannot be regarded as conclusive.

Entomology.

Cabbage root fly and carrot fly.—Experiments on the control of these pests have been continued. Preliminary work has been carried out in connection with attractants. Balloon traps were baited with various substances and placed among carrots and Brussels sprouts in an infested area at Everton Heath. No carrot flies and only a few cabbage root flies were obtained. As a result of this work it will be possible next year to eliminate as useless certain of the substances tested and to use on a more extensive scale others which are likely to be effective.

Experiments were conducted on the control of carrot fly by means of naphthalene. The results of this work will not be available until the crop is lifted. A large cage-trap, similar to that used in previous seasons, was placed in the carrot field and a periodical census of insects was taken. *Caveriella aegopodia S.* was identified as one of the species of aphis causing serious damage to carrots in the Everton Heath district.

Miscellaneous.—A multiple temperature incubator has been constructed. One of the first problems in which it will be used is the determination of the temperature required for the emergence of the cabbage root fly from its pupa. Since this fly is extremely elusive, even to a trained eye, it is hoped that it may be possible, as a result of the experiments, to warn growers of the necessity of treating their crops for this pest when the temperature reaches a certain level (or when the temperature has reached a certain level at various times during a given period) without waiting to see whether the fly is actually present in the crop.

Pupae of the blow fly (*Calliphora*) placed in cold storage in June, 1933, were brought out in batches in July. The flies on emerging were placed in bags enclosing onion inflorescences and proved of great value in assisting the work of self-pollination.

Titles of papers issued during the year.

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3. ————: A partial phase rule investigation of miscible oil system phenol-water-sodium oleate-toluene. *Ibid.*, **52**, 185T, 1933.
4. ————: Emulsion systems containing phenols, water and gelatin. *Ibid.*, **52**, 44T, 1933.
5. Woodman, R. M., and Rhodes, E.: Notes on quebrachitol and the lipin from *Hevea latex*. *J. Rubber Res. Inst. Malaya*, **4**, 2, 1, 1932.

16. EXPERIMENTAL AND RESEARCH STATION, CHESHUNT.

Manurial and Crop Management Trials.

Tomatoes.

Manurial and crop management trials with tomatoes have been continued. The experiments with nitrogenous fertilisers, which have been in progress for four years suggest that when they are applied as top dressings continually through the season the effects of sulphate of ammonia, nitrate of soda and nitrate of lime are fairly uniform. During normal weather, Peruvian guano, dried blood and fish meal also give similar results, but seem slightly more effective than those mentioned above. During years of abundant sunshine, when adequate supplies of nitrogen are particularly necessary, dried blood and fish meal were most beneficial. As a base fertiliser, hoof and horn gave better results in the first year than cyanamide, and better results than shoddy for the first three years, but the accumulative effect of applying shoddy each year was seen in the fourth year when the yield from the shoddy plot exceeded slightly that from the hoof and horn plot. Applications of cyanamide to the soil three months before planting have given good results, especially during the second and fourth years, and the effect of this compound must be investigated further.

The experiment of planting in trenches, which were filled in as soon as the lowest trusses had been picked, has not given the results which were expected. Soil conditions at the bottom of a six inch trench do not encourage root production as well as those near the surface, and root injury has resulted each year. On lighter and warmer soils the method may be advantageous, but it is not suitable for heavy compact soils.

Experiments concerned with the improvement of physical conditions by incorporating straw, peat, spent hops and chrysanthemum

roots have been continued. The use of clean wheat or oat straw, placed vertically in the soil to a depth of twenty inches can be recommended to growers as a means of improving heavy and medium soils.

Peat is also useful, but heavy dressings are required and the cost is probably too high for commercial work unless a source of good material exists near to the nursery. The results of adding spent hops are variable. The first year's crop usually shows an appreciable increase, but the effect does not seem to be lasting, and some reduction in yield has been observed in the second year.

Chysanthemum roots have given good results when healthy material is used, but the tomato crop has been adversely affected after using diseased roots. As particular care must be given to the selection of the material which can be employed with safety, the use of chrysanthemum roots for increasing the organic matter in the soil cannot be recommended as a general practice.

The liming experiment which has been in progress during the past six years, indicates clearly that the tomato can tolerate a certain degree of soil acidity. The value of liming has been over estimated in the past, and while light dressings constitute a safety measure, heavy dressings can be recommended only for the purpose of improving the physical condition of heavy clay soils.

The variety trials proved particularly interesting this year, because they showed why the Kondine Red and Best of all types are so popular in the warmer sunny areas of the country. This variety thrived under the exceptional summer conditions, and produced crops which were abnormally heavy for the Lea Valley district.

The highest yields, however, came from the Guernsey strain of Radio, and another Guernsey type, Radio x Kondine Red. The varieties resistant to leaf mould retained their resistance and are producing heavier crops of good quality fruit as the result of continued selection. The best type was Stirling Castle X E.S.I., while Up-to-date x Tuckswood promises to be good after further selection.

The soil heating experiments with tomatoes were extended and it has been possible to make definite recommendations for heating the soil on commercial nurseries by means of a system of buried hot water pipes. A crop increase of some 30 per cent. was obtained on a fairly large scale as the result of raising the soil temperature from 65° F. to 80° F.

Cucumbers.

Similar investigations with cucumber beds are in progress, and indicate as before that healthier plants and heavier crops can be produced by warming the soil artificially.

The oil fuel experiment was continued and while excellent temperature control was obtained the cost of fuel proved higher than when anthracite is employed.

Experiments were begun with the Iron Fireman type of automatic stoker, which uses a cheap form of soft coal. This is driven electrically and is thermostatically controlled. Preliminary results are promising.

Lettuce.

Work with the new winter forcing lettuce " Cheshunt Early Giant " is being continued. An excellent crop of well hearted lettuce was marketed during the last fortnight in February from plants set out in the houses during the first week of the previous December. Also a crop of good, firm heads was marketed at Christmas from plants planted on 5th October, following removal of the tomato plants. This variety is a great improvement on existing types, for it reaches maturity some three weeks earlier, and develops solid hearts during short days. It is hoped that seeds will be available to growers in time for the next winter crop.

Pests and Diseases.

Satisfactory results in the control of the tomato-moth caterpillar have been obtained on an experimental scale by spraying plants with a mixture of synthetic Cryolite (aluminium sodium fluoride) and rape oil, as a substitute for lead arsenate. A tomato house into which many caterpillars had been introduced, and which was sprayed once every six weeks during the growing season, was free of the pest in August and September. A good crop was obtained from the plants, and deposit upon the fruit due to spraying was easily removed by wiping. For spraying purposes the admixture of an oil is necessary to bring about adhesion of the Cryolite to the foliage, and only certain types of Cryolite can be mixed with an oil. These have been difficult to obtain, but recently a colloidal Cryolite has been manufactured which may prove of value, especially for use on nurseries where lettuce is grown in tomato houses.

In July, 1933, a chalcid parasite (*Comedo spaculus* Thoms.) of the tomato-moth caterpillar made its first appearance at the Station. A close study has been made of its remarkable habits and life-history, and a stock of chrysalids is being kept over the winter. In addition, it has been possible to breed the parasite in small numbers during the winter months on caterpillars of the angle-shades moth. It is doubtful, however, if this parasite will have any appreciable effect in the control of the tomato moth upon commercial nurseries.

An investigation into the habits of the ichneumon parasite (*Pimpla instigator* L.) is being undertaken with a view to increasing the number of this useful insect in tomato houses.

Certain spray fluids purporting to contain Rotenone have been tested upon the red spider mite on the tomato plant. Solutions of rotenone in acetone have been similarly tested. The results have been unsatisfactory.

As some 70 per cent. of the mites upon the foliage are in the egg stage during the greater part of the growing season, no spray or fumigant which is without ovicidal action, or the killing properties of which do not last for a number of days upon the foliage, can be of much value in controlling this pest.

Since 1924, the grubs of one of cecidomyid flies (*Therodiplosis persicae* Kieff), which feed upon the red spider mite, have annually become more prevalent in tomato houses in the Lea Valley. They have also been observed upon strawberry plants and peach trees grown under glass, but do not occur in cucumber houses. Attempts are being made to discover how the insect passes the winter.

The onion thrips (*Thrips tabaci*, Lind.) as a vector of spotted wilt disease, must now be regarded as an important pest of the tomato plant. Although the insect breeds mostly upon the cucumber plant and in the flowers of carnation, cyclamen and arum, it frequently attacks the tomato, and can carry infection from a former host even after a period of hibernation in the soil. Control measures consist in steaming the soil in winter, and eradicating weeds, especially yarrow, from the vicinity of glasshouses, near which it is undesirable also to grow potatoes or onions.

The millepede *Blanjulus guttulatus* often occurs in undesirable numbers in the soil of tomato houses, though damage to the roots by it has not been proved. The amount of naphthalene to be dug into the soil during the autumn in order to kill these millepedes is found to be at least 8 ounces per square yard, i.e., about four times the amount usually applied upon commercial nurseries. Many other compounds have been tested in commercial cucumber houses, but it was found that the method of spreading naphthalene over the borders gave the most satisfactory control.

The breeding and distribution of the white fly parasite (*Encarsia formosa*, Gehan), has been continued. This parasite is in considerable demand.

The investigation of " leafy gall " of the chrysanthemum has been continued, paying particular attention to the question of control. When cuttings were taken from apparently clean plants the extent of the infection in the mature plants was about 30 per cent., but with cuttings from infected plants the infection rate was between 50 per cent. and 80 per cent. in the different batches. A reduction in percentage infection was also obtained by adding a little calcium sulphate to the compost in which the cuttings were inserted, but this compound was not effective when treatment was delayed until the rooted cuttings were potted into three inch pots. The organism described in the previous report has been isolated again this year, and inoculation experiments were again inconclusive.

The investigation of rose diseases mainly rust, powdery mildew and die-back has been continued. Experiments have shown that a satisfactory control of rose mildew may be achieved by spraying with an oil and copper compound.

Virus diseases.

Various factors connected with the physical and chemical nature of soils have been studied in relation to the incidence and severity of virus diseases of the tomato.

Samples of soil were obtained from nurseries where mosaic diseases are both prevalent and serious. It was found that when tomato plants grown in these soils and also in water logged soils, were inoculated with aucuba mosaic, the disease was more pronounced than in a similar series of inoculated plants grown in a standard compost. No evidence was obtained to suggest that such soil conditions are solely responsible for the presence of virus diseases.

In addition it was found that the presence of plant poisons in the soil increased the severity of the disease in tomato plants inoculated with aucuba mosaic but numerous tests in soil and water cultures failed to produce symptoms of virus diseases in uninoculated plants.

From a pot experiment it was found that applications of a readily available nitrogenous top dressing (such as dried blood) reduced the quantity of marked fruit from aucuba mosaic infected tomatoes.

The investigation of the effect of aucuba mosaic on the carbohydrate metabolism of the tomato has been continued.

The most outstanding difference between the metabolism of diseased plants and that of healthy plants is the time lag in the formation in the laminae, of non-reducing sugars from reducing sugars in diseased plants.

The investigation of tomato diseases of the streak group was continued. From an experiment with seed from streaked tomatoes it was concluded that virus is absent from the embryo, though present in the seed coat, of seed from infected fruit.

With the co-operation of Dr. G. H. Berkeley of St. Catherine's Laboratory, Ontario, a comparison of Canadian tomato diseases of the mosaic-streak type with the corresponding English diseases has been started.

The study of spotted wilt was continued. This disease was recorded from thirteen English counties, from Wales and from Ireland during the season and was the subject of a special circular.

The mosaic diseases of the cucumber have been examined and two types described. One type can only infect the cucumber and allied plants while the other has a much wider host range and causes true fern leaf of tomato.

An attempt has been made by means of manurial experiments in pots to demonstrate the effect of different treatments upon the severity of aucuba mosaic disease.

Other investigations.

During the present year, the technique developed during 1932, has been applied to a study of the relationship between light, temperature and assimilation rate of the seedling tomato, variety E.S.I. It has been shown that the assimilation rate falls steadily from mid-summer to the period around the shortest day and that there is a marked seasonal variation in the assimilation rate. The relationship between light, temperature and assimilation is complicated, and can be illustrated best by means of a three demensional model, one of which has been constructed. From this model it is possible to determine the optimum temperature for assimilation at a given light intensity.

The water content of the tissues has also been shown to exert a profound influence on assimilation and tends to be too high in winter and too low in summer.

New methods have been evolved for the investigation of the part played by water in the economy of the tomato plant and it is now possible to investigate tension of the cell wall, osmotic pressure of the cell sap and water content of tissues in a manner that has hitherto been considered impossible. Investigations along these lines are in progress. The preliminary investigation of a device for obtaining a constant light record has been made and the construction of a permanent recorder is well advanced. This should be of considerable value.

Preliminary studies of the conditions affecting translocation, leaf expansion and root development in the seedling tomato have been completed but the data have not yet been examined critically.

Work has been continued on the nitrates in tomato soil. Some evidence has been obtained to show that excess of nitrates depress the activity of the factor causing the disappearance of nitrates. In view of the beneficial effects of a first application of spent hops on the tomato crop the fluctuations in nitrates in a spent hop plot were followed. In this plot nitrates were always higher than in an untreated plot and in a plot containing peat. It may be of significance that the moisture content of the soil was always highest where spent hops had been added.

The effect of the omission of soil nutrients on the nitrogen contents of some market garden crops has been examined. In chrysanthemums and beetroots omission of nitrogen, phosphates or potash depress the nitrogen content. Omission of potash did not depress the nitrogen content of cabbage foliage, beet foliage and carrot roots. Omission of phosphates did not depress the nitrogen content of runner bean foliage and pods and carrot foliage.

Titles of papers issued during the year.

1. Ainsworth, G. C.: An investigation of tomato virus diseases of the mosaic " stripe " streak group. *Ann. Appl. Biol.*, **20**, 3, 421-428, Aug., 1933.

2. Bolas, B. D., and Melville, R.: The influence of environment on the growth and metabolism of the tomato plant. I. Methods, technique and preliminary results. *Ann. Bot.*, **47**, 187, July, 1933.
3. Read, W. H., and Orchard, O. B.: Plant injury following the burning of sulphur in vacant glasshouses. *J. Min. Agric.*, **39**, 12, 1085-1087. 1933.
4. Eighteenth Annual Report, 1932-33.
5. Circular No. 7: Spotted wilt of tomatoes.
6. Circular No. 8: The cultivation of lettuce in glasshouses.

17. JOHN INNES HORTICULTURAL INSTITUTION, MERTON, LONDON.

Sir Daniel Hall, in a paper read before the Linnean Society, considered the taxonomy and cytology of the scarlet tulips of the Near East (22). He has also contributed a note to the Gardener's Chronicle on the Institution's rather extensive collection of Tulip species (23). In collaboration with Mr. Crane he has published a book on the apple (36) intended to bring before the practical grower the results of recent scientific work. Dr. Collins and Mr. Mather have discussed the genus *Crocus* (4).

Prof. J. B. S. Haldane has continued his mathematical theory of evolution with a paper on " the part played by recurrent mutation in evolution " (21) and has also published two short papers on human heredity (19, 20). He has collaborated in genetical studies on *Primula sinensis* (16) and *Antirrhinum* (17).

Dr. Darlington, who was abroad during the whole of the academic year, published five short papers on chromosome behaviour in various plants and animals (9, 10, 11, 12, 13).

In collaboration with Prof. Haldane, Miss de Winton has published the second of the series of detailed papers on *Primula sinensis* (16), and Miss Gairdner a second paper on her strain of *Antirrhinum* which shows a balanced lethal mechanism (17). Dr. Sansome has published the first results of his comparative genetical work in diploid and tetraploid tomatoes (34) and Dr. Philp has concluded a long series of experiments on species hybrids in oats (33).

Dr. Moffett, in addition to work on fruit (31) has published a paper on the cytology of *Anemone*, which shows some curious abnormalities (30). Mr. Dark has published his results on the Coniferae, which have a constant chromosome number n = 12 except for some cases of triploidy (8). He has also worked on *Hemerocallis* (7). Dr. Mather has published a theoretical paper on *Drosophila* genetics (29) and one on chromosome behaviour in collaboration with Dr. Darlington (14). Mr. Larter, working at the Institution as a post-graduate student, has investigated the cytology of *Ranunculus* in connection with Mr. Marsden Jones' and Dr. Turrill's experiments at Potterne (26). Dr. Koller, also a visitor, has published the results of a re-examination of material

of *Tradescantia* and *Rhoeo* (25). Mr. Afify has worked on *Aconitum* (1) and on pollen-tube growth (2).

The work on fruit has been continued and the pollination experiments extended to pears. Mr. Crane has collaborated with Dr. Zilva of the Lister Institute in a further paper on Vitamin C in polyploid apples (6).

Miss Cayley has been occupied largely with myxomycetes and *Psalliota*. Some further results have been obtained on the transmission of the virus of tulip breaking (24), and Mr. McKenny Hughes has further experiments in progress. Miss Andersson-Kottö has in preparation an account of her "peculiar" sporophytes in *Scolopendrium*, and the theoretical bearing of the data on the question of apospory and alternation of generations in the Ferns.

Dr. Brieger, late of Berlin, who recently joined the staff, is initiating with Mr. A. Fabergé a series of physiological experiments on genetic material. Miss R. Scott-Moncrieff has been collaborating on the biochemical side of the genetic experiments with *Dahlia*, *Primula sinensis* and *Papaver*. With Mr. Lawrence she has in the press a detailed account of genetical, cytological and biochemical work on *Dahlia variabilis*.

Papers issued during the year.

1. Afify, A.: Chromosome form and behaviour in diploid and triploid *Aconitum*. *J. Genet.*, **27**, 293-318, 1933.
2. ———: Pollen tube growth in diploid and polyploid fruits. *J. Pomol.*, **11**, 113-119, 1933.
3. Buxton, B. H., and Darlington, C. D.: Crosses between *Digitalis purpurea* and *Digitalis ambigua*. *New Phytol.*, **31**, 225-240, 1932.
4. Collins, E. J., and Mather, K.: The genus *Crocus* and its cytology. *Proc. Linn. Soc.*, **145**, 114-118, 1933.
5. Crane, M.B.: The chromosome constitution and pollination of apples. *Gard. Chron.*, **92**, 309-310, 1932.
6. Crane, M. B., and Zilva, S. S.: The antiscorbutic potency of apples. *Biochem. J.*, **26**, 2177-2181, 1932.
7. Dark, S. O. S.: Meiosis in diploid and triploid *Hemerocallis*. *New Phytol.*, **31**, 310-320, 1932.
8. ———: Chromosomes of *Taxus*, *Sequoia*, *Cryptomeria* and *Thuya*. *Ann. Bot.*, **46**, 965-977, 1932.
9. Darlington, C. D.: The origin and behaviour of chiasmata V. *Chorthippus elegans*. *Biol. Bull.*, **63**, 357-367, 1932.
10. ———: The origin and behaviour of chiasmata VI. *Hyacinthus amethystinus*. *Ibid.*, **63**, 368-371, 1932.
11. ———: The behaviour of interchange heterozygotes in *Oenothera*. *Proc. Nat. Acad. Sci.*, **19**, 101-103, 1933.
12. ———: Meiosis in *Agapanthus* and *Kniphofia*. *Cytologia*, **4**, 229-240, 1933.
13. ———: The origin and behaviour of chiasmata VIII. *Secale cereale* (n,8). *Ibid.*, **4**, 444-452, 1933.
14. Darlington, C. D., and Mather, K.: The origin and behaviour of chiasmata III. Triploid *Tulipa*. *Ibid.*, **4**, 1-15, 1932.
15. De Winton, D.: Leaf and bract forms of *Primula sinensis* and their inheritance. *Proc. Linn. Soc.*, **145**, 89-91, 1933.

16. De Winton, D., and Haldane, J. B. S.: The genetics of *Primula sinensis*. II. Segregation and interaction of factors in the diploid. *J. Genet.*, **27**, 1-44, 1933.
17. Gairdner, A. E., and Haldane, J. B. S.: A case of balanced lethal factors in *Antirrhinum majus*. II. *Ibid.*, **27**, 287-291, 1933.
18. Haldane, J. B. S.: Note on a fallacious method of avoiding selection. *Amer. Nat.*, **66**, 479-480, 1932.
19. ————: Genetical evidence for a cytological abnormality in man. *J. Genet.*, **26**, 341-344, 1932.
20. ————: The genetics of cancer. *Nature*, **132**, 265-267, 1933.
21. ————: The part played by recurrent mutation in evolution. *Amer. Nat.*, **67**, 5-19, 1933.
22. Hall, Sir A. Daniel: The scarlet tulip of the Near East, *Tulipa oculis-solis*. *Proc. Linn. Soc.*, **145**, 121-123, 1933.
23. ————: Notes on tulip species. *Gard. Chron.*, **93**, 316-317, 1933.
24. ————: Transmission of tulip breaking. *Gard. Chron.*, **93**, 331, 1933.
25. Koller, P. C.: Further studies on *Tradescantia virginiana* var. *humilis* and *Rhoeo discolor*. *J. Genet.*, **26**, 81-96, 1932.
26. Larter, L. N. H.: Chromosome variation and behaviour in *Ranunculus* L. *J. Genet.*, **26**, 255-283, 1932.
27. Lawrence, W. J. C.: Interaction of flavones and anthocyanins. *Nature*, **129**, 834-835, 1932.
28. ————: The origin and genetics of the garden Dahlia. *Proc. Linn. Soc.*, **145**, 49-51, 1933.
29. Mather, K.: The relation between chiasmata and crossing-over in diploid and triploid *Drosophila melanogaster*. *J. Genet.*, **27**, 243-259, 1933.
30. Moffett, A. A.: Chromosome studies in Anemone, I. A new type of chiasma behaviour. *Cytologia*, **4**, 26-37, 1933.
31. ————: Note on the cytology of *Prunus* rootstocks. *J. Pomol.*, **10**, 181-183, 1932.
32. Philp, J.: Fatuoid or false wild oats. *Nature*, **129**, 796, 1932.
33. ————: The genetics and cytology of some inter-specific hybrids of *Avena*. *J. Genet.*, **27**, 133-180, 1933.
34. Sansome, F. W.: Chromatid segregation in *Solanum Lycopersicum*. *J. Genet.*, **27**, 105-132, 1933.
35. Stone, L. H. A., and Mather, K.: The origin and behaviour of chiasmata. IV. Diploid and triploid *Hyacinthus*. *Cytologia*, **4**, 16-25, 1932.
36. Hall, Sir A. D., and Crane, M. B.: The Apple. Martin Hopkinson, Ltd., London, 1933.

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ENTOMOLOGY AND PLANT PATHOLOGY

18. PLANT PATHOLOGICAL LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

The activities of the laboratory are primarily concerned with administrative and advisory questions relating to diseases and pests of plants, and research is carried out only in so far as other duties permit. Instances of the activities of the laboratory during the year under review are as follows :—

In collaboration with the Ministry's Inspectorate, an extensive range of imported plants or plant produce has been examined in connection with the possible introduction of plant diseases and pests. The further development of the Colorado Beetle situation necessitated a close inspection of the areas likely to be infested and culminated in the discovery of a colony of the pest near Tilbury. The problem of preventing the introduction of the Cherry Fruit Fly and the Potato Moth with imported cherries and potatoes again involved consideration owing to the development of new sources of supply from countries overseas. The increasing use of insecticides and fungicides, resulting in a demand on the part of the public concerned for the standardisation of the materials employed, has necessitated the investigation of measures adopted by other countries for testing and standardisation, and also discussions with manufacturers on methods of dealing with the problem in this country.

Further attention has been paid to an alleged " degeneration " in Golden Spur daffodils, whilst the effect of a somewhat pronounced superficial development of one of the common moulds on the outer scales of tulip bulbs on the growth and flowering of such bulbs is under investigation. Experiments on Marsh Spot of pea seeds have been continued and have shown that, although some of the seedlings from affected seed may be more or less weak and to some extent mutilated, yet they often produce reasonably good plants with a fair crop of seed. In the soil of the laboratory garden, a stiff clay resting on chalk, the seed from such a crop has always been almost free from Marsh Spot. Arrangements have been made for carrying on field studies on Marsh Spot, with Wye College, Kent, as headquarters, with the object of ascertaining whether any correlation exists between soil type and occurrence of

Marsh Spot. An obscure disease of Pelargonium, characterised by spotting, crinkling and puckering of the foliage, has been investigated and shown to be probably a virus disease of the mosaic type (1). Considerable attention has been devoted to the Rusts of Antirrhinum (*Puccinia Antirrhini*) and Asparagus (*P. Asparagi*), as a result of severe outbreaks of these two fungi in 1933.

Experimental work on the culture of Pyrethrum for insecticidal purposes was continued and, in addition to the plots on a semi-commercial scale previously referred to, a small scale manurial plot experiment at the Woburn Experimental farm was started in collaboration with Rothamsted. The results from the larger plots tend to confirm the view that labour costs are likely to be the determining factor in regard to the commercial cultivation of Pyrethrum in England.

Further liberations of the Woolly Aphis parasite *Aphelinus mali*, obtained from a stock reared at the laboratory have been made in likely centres, in certain cases with better results than usual, doubtless owing to the dry warm summer.

Titles of papers issued during the year.

1. Pethybridge, G. H., and Smith, K. M.: A suspected virus disease of Zonal Pelargoniums. *Gard, Chron.*, **92**, 378-379, 1932.
2. Gimingham, C. T.: Winter spraying of fruit trees in England. *Rev. Path. Vég. et Ent. Agric.*, **19**, 40, 1932.
3. Fryer, J. C. F., Gimingham, C. T., and Buckhurst, A. S.: Report on insect pests of crops in England and Wales, 1928-1931. *Bull.* 66, *Min. Agric.*, 1933.
4. Fryer, J. C. F.: Pests and parasites. Farmers' Guide, 1931. Roy. Agric. Soc., 1932.

19. POTATO VIRUS RESEARCH STATION, CAMBRIDGE UNIVERSITY.

Raising of virus-free stocks.

The virus-free stocks raised in previous years have all been maintained, the basic stocks by pot culture in the insect-proof glass-house and the " 1st year out " stocks derived from last year's pot culture by growth in isolation in corn-fields.

Additional virus-free stocks are Arran Cairn, Ninetyfold, and Kathardin.

The following varieties were grown and tested with a view to raising clean stocks, viz., Queen Mary, The Baron, and Institut de Beauvais, but no virus-free units were recovered.

The outside plots of 1933 consisted of " 1st year out " material only. The health of the plants was perfect and there was evidence of only very occasional seasonal infection; such plants were eradicated.

Attention has been concentrated on the discovery of biotypes of the X virus, of which three have been isolated and a possible fourth is under consideration.

It has been found possible to inoculate protectively tobacco and Datura plants with the less virulent of the X strains against subsequent inoculation with the more severe.

In conjunction with the School of Pathology, antisera have been prepared in rabbits against two of the X biotypes; precipitation and neutralisation tests with both are giving promising results.

Research has continued on the streak diseases of the potato; infra-red photography has been employed with interesting results.

The work on raising varieties resistant to *Phytophthora infestans* has been continued. Numerous seedlings with fair economic qualities have now been secured, all of which are resistant to the Phytophthora blight in the field and some of which are also resistant to what appears to be a new type of the fungus which was isolated last year.

Entomology.

Work has been continued upon the insect vectors of the virus diseases of the potato and particular attention has been paid to investigations upon the mode of transmission in the field of the common potato mosaic virus known as X.

Studies upon the physical properties of viruses affecting the potato and allied plants are being pursued in an endeavour to find a stable means of identification and classification of these viruses.

Some investigation upon virus problems of local importance has also been carried out and these include tomato spotted wilt and sugar beet mosaic.

Titles of papers issued during the year.

1. Bawden, F. C.: Infra-red photography and plant virus diseases. *Nature*, **132**, July 29, 1933.
2. O'Connor, C.: Potato breeding and resistance to blight. *Gard. Chron.*, Feb. 11, 1933.
3. Salaman, R. N.: Protective inoculation against a plant virus. *Nature*, **131**, April 1, 1933.
4. ————: Report of the Potato Synonym Committee for 1933. *J.N.I.A.B.*, 1934.
5. Smith, K. M., and Pethybridge, G. H.: A suspected virus disease of zonal pelargoniums. *Gard. Chron.*, **92**, 378-379, 1932.
6. Smith, K. M.: Spotted wilt: an important virus disease of the tomato. *J. Min. Agric.*, **39**, 12, 1933.
7. ————: The present status of plant virus research. *Biol. Rev.*, **8**, 2, 136-179, 1933.
8. ————: Some virus diseases of the potato and other farm crops. *Scot. J. Agric.*, **16**, 4, 444-456, 1933.
9. ————: Recent advances in the study of plant viruses. J. and A. Churchill, London, 1933.

20. PLANT PATHOLOGICAL LABORATORY, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

The work of the Plant Pathological Laboratory of the Department of Agriculture for Scotland covers a wide field. Research has been continued as the exigencies of general work permitted, in conjunction with the Mycological Department of the University of Edinburgh and the Agricultural Colleges.

General advisory work.—Some 400 cases of disease were dealt with, including a case of pink rot of potato (*Phytophthora erythroseptica*) which upon investigation was found to be transmitted in damp sphagnum moss.

Wart disease.—Mycological determinations of the wart disease tests were carried out by the Department for the Inter-Departmental Committee. Out of this work some interesting questions have arisen, and experiments and observations on certain points in the life history of the fungus are being undertaken.

Strawberry disease investigation.—The trials in the field of varieties of strawberries in relation to resistance to the *Phytophthora* root-rot are being continued. The present varieties show a certain range of resistance and many new varieties are being tried in diseased land.

Among the new seedlings some show more resistance than any variety so far tried. The work is being concentrated on a search for immunity rather than on chemical treatments for the soil. This research is undertaken in conjunction with the West of Scotland Agricultural College.

Other Phytophthora diseases.—A Root-rot of raspberry caused by a *Phytophthora* is being investigated.

A *Phytophthora* causing a damping-off of primula and meconopsis seedlings was investigated in the spring with the assistance of the Imperial Mycological Institute. Its specific name has not been determined, and it is hoped to do some further work on this possibly general trouble.

A *Phytophthora* that was determined by Dr. Ashby as *Phytophthora cactorum* var. *applanata* caused great destruction as a root and crown rot of the Japonica group of the primulas (mature plants) in May and June in Scotland.

The work on the *Phytophthora* on Leek is being continued.

Seed-borne diseases.—The small *Sclerotinia* disease on the seeds of white clover from abroad has now been found by the Seed Testing Station on English wild white clover, and the fungus grown in culture and verified at this laboratory.

A research on seed-borne diseases of certain vegetable crops and their control is being carried on in conjunction with this Laboratory by the Mycological Department of the University of Edinburgh.

Title of paper issued during the year.

Alcock, N. L.: Downy mildew of *Meconopsis*. *The New Flora and Silva*, July, 1933.

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21. (SEED TESTING AND) PLANT DISEASE DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Plant Pathology.

Cereal diseases.

Disinfection of seed oats.—Further work has been carried out on the investigation of problems connected with the disinfection of seed oats with organic mercury dusts, etc. The use of this method of disinfection is steadily growing in routine farm practice. The spring of 1933 was very suitable for the growth of the crop in its early stages, but even so, a significant increase in crop yield was recorded in many cases as a result of seed disinfection. Previous work (3) has already shown that this method secures almost complete control of smuts (*Ustilago avenae* (Pers.) Jens and *Ustilago Kolleri* Wille) and that it provides a satisfactory remedy for leaf stripe (*Helminthosporium Avenae* Eidam). At the same time it is indicated that the beneficial results following upon treatment cannot be entirely attributed to the control of smuts and leaf stripe. The work in progress has already thrown some light upon the seasonal and soil conditions under which disinfection is likely to prove most beneficial, and also upon the conditions liable to produce seed injury resultant upon disinfection.

During the year a series of large scale field experiments have been carried out in collaboration with the County Instructors in Agriculture. The small scale field experiments were carried out at the Agricultural Research Institute for Northern Ireland, Hillsborough, County Down.

Potato diseases.

Ordinary or late blight (*Phytophthora infestans* (Mont.) de Bary). —The study of varietal susceptibility to blight of haulms and tubers of potato varieties grown in Northern Ireland has been continued for a third year. The value of efficient "earthing up" of the drills as a control measure to prevent tuber attack has also been demonstrated.

A series of spraying trials carried out to compare the values of various proprietary copper fungicides with that of Burgundy mixture gave results which indicated once more that Burgundy mixture is superior to any of the other materials used.

Pink rot (*Phytophthora erythroseptica* Pethybr.).—The results obtained in the investigation of this disease up to the end of 1932 have been published (1). It has been shown that the disease is widespread, but only occasionally of serious economic importance. Whereas *Phytophthora erythroseptica* is the normal pathogene, in one instance the disease was found being caused in the field by *P. megasperma* Drechsler. The disease may be systemic in the plant thereby causing " misses " and " pink rot wilt " in the crop. It may cause heavy losses during storage under conditions of high humidity and poor aeration. No variety of the potato has been found to be particularly resistant. The disease may be satisfactorily controlled in the field by paying sufficient attention to the general principles of plant hygiene.

Disinfection of tubers.—Further preliminary trials were carried out with a view to investigating the value of various disinfectants in controlling surface-borne diseases of the potato tuber, such as common scab (*Actinomyces scabies* (Thaxh.) Güss.), powdery scab (*Spongospora subterranea* (Wallr.) Lagerh.) and black scurf (*Corticium Solani* Bourd. and Galz.). It is hoped to give special attention to this problem during the coming year.

Fruit diseases.

Apple scab (*Venturia inaequalis* Aderh.).—The experimental centres used for 1933 were orchards which had been subjected to a comprehensive scheme of spraying and as a consequence the outbreak of scab was so slight that significant results indicating the relative values of the various fungicides used were not obtained.

Gooseberry rust (*Puccinia Pringsheimiana* Kleb.).—Outbreaks of this disease have become more serious during the past few seasons and a general investigation has been commenced. Some success has already been obtained by spraying the bushes with a weak copper fungicide in early spring. A study of the extent of the occurrence of the alternate stage of the parasite on *Carex spp* is being made.

Vegetable diseases.

Finger and toe of brassicae (*Plasmodiophora Brassicae* Woron.).—An account of the work carried out in 1931 and dealing with the control of this disease in broccoli has been published (3). The application of a half pint of a solution of mercuric chloride (0·01 per cent.) to the hole made to receive each plant at the time of transplanting has given excellent results for three seasons. The use of a stronger solution was of no additional advantage, while mercurous

chloride (calomel) proved to be definitely inferior. The use of lime sulphur for this purpose was of little value. The beneficial effect of lime in securing the control of the disease was made apparent in the second season and repeated dressings over a period of years may secure perfect control. The use of mercuric chloride appears to be highly satisfactory for securing immediate control of the disease in infected land which is urgently needed for the cultivation of crops of brassicae.

Diseases of ornamental plants.

Rose rust (*Phragmidium mucronatum* (Pers.) (Schlecht.).—The results of summer spraying trials have been published (4). These results were obtained for one year only (1932) and indicate that a fairly satisfactory measure of control may be obtained by the use of a sulphur spray. Four sprayings were applied in these experiments. The use of a colloidal form of sulphur gave better results than liver of sulphur. Soft soap was added to enhance the spreading power of the spray fluid. Bordeaux mixture was satisfactory as a fungicide, but caused disfiguration of the foliage, etc. A proprietary copper fungicide gave good control and did not disfigure the foliage, but caused an undesirable hardening and bronzing of the leaves.

These conclusions have been more or less confirmed by experiments carried out during 1933. For this year the proprietary copper fungicide caused no hardening or bronzing of the leaves and gave results equivalent to those obtained by the use of colloidal sulphur.

Carnation wilt (*Fusarium cumorum* (W.G.Sm.) Sacc.).—The effect of sterilisation of the soil by steam in order to obtain control of this disease, is being investigated.

Forest tree diseases.

Further experiments have been conducted during the year in order to compare the relative values of sulphuric acid and aluminum sulphate for controlling diseases and weeds in the forest nursery.

Economic Entomology.

Apple tree pests.

Winter washes.—A number of tar-distillate spray fluids, including some home-made and some of a proprietary nature, were tested as dormant sprays in County Antrim. Observations relating to their egg-killing properties and their value for general cleansing purposes were made.

Capsid bugs.—Further experiments were conducted in County Armagh with a view to securing control of capsid bugs. Petroleum oil emulsions and combination sprays incorporating both petroleum

oils and tar-distillates were applied, and their behaviour at different concentrations was noted. Information concerning the relationship between the date of application and the degree of spray injury to young growth was also obtained.

Red spider.—Investigations as to suitable treatments for the control of this pest were carried out along similar lines to those adopted last year. Centres with heavy infestation were chosen in County Armagh and County Antrim and the effects of spraying with petroleum oils in spring and with various forms of sulphur in summer were observed.

Black currant pests.

Big bud mite.—Using polysulphide sprays, colloidal sulphur, dusting sulphur and mineral oils on a series of experimental plots in County Antrim, data were obtained upon which preventive and remedial measures can be based. Although successful control of the big bud mite has been achieved, further inquiry is being directed towards a means of preventing the foliage injury resulting from the use of sulphur in its various forms under conditions prevailing in Northern Ireland.

Vegetable pests.

Carrot fly.—A repetition of last year's experiment at a new centre in County Down gave further evidence of the value of naphthalene as a repellent to the adult fly. Both from a scientific and an economic standpoint, repeated dressing of this substance gave the most satisfactory control. Other treatments included dressings of creosoted-chalk dust and watering with a weak solution of a tar-distillate wash.

Titles of papers issued during the year.

1. Cairns, H., and Muskett, A. E.: Pink rot of the potato. *Ann. App. Biol.*, **20**, 381-403, 1933.
2. Muskett, A. E., and Cairns, H.: The effect of seed disinfection upon the oat crop. *J. Min. Agric. N.I.*, **4**, 105-115, 1933.
3. Baillie, D. W., and Muskett, A. E.: The control of finger and toe of broccoli in County Down. *Ibid.*, **4**, 44-46, 1933.
4. Muskett, A. E., and Taylor, J. C.: The control of rose rust by summer spraying. *Ibid.*, **4**, 62-66, 1933.

E

AGRICULTURAL PARASITOLOGY

22. INSTITUTE OF AGRICULTURAL PARASITOLOGY, LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE.

Infestation of farm stock, poultry and game.—The studies on the effect of the " New System of Grassland Management " on the worm burden of sheep and goats which were described in last year's report (4) have been continued under the very different climatic conditions of the past summer and a comparison of the results when available should prove of considerable interest. After several ineffectual attempts several lambs and kids have been reared worm-free from birth and have provided a means of starting several new experiments viz. :—(*a*) Pure live strains of *Bunostomum trigonocephalum*, *Haemonchus contortus*, *Chabertia ovina*, and *Ostertagia circumcincta*, *Muellerius capillaris*, *Bilharzia bovis*, and *Bilharzia Mattheei;* (*b*) age immunity of sheep and goats to helminths; (*c*) duration of residual infection on infected pastures. The survival of helminth larvae in tubes of sterilised earth buried in soil has been studied monthly, and a series of observations on helminths, especially " gapes ", in partridges, pheasants, and turkeys has also been made.

Effect of dietary deficiencies on helminth infestation.—The experiments dealing with the effect of dietary deficiencies on helminth infestation have been continued (1, 2). The mineral content of the diet has been found to affect significantly the number of *Heterakis gallinae* present in the chicken. Neither the minerals nor the Vitamin A seem to have any appreciable effect on the gape-worm, although an old cockerel, on a Vitamin A deficient diet, was successfully infested with a single pair of gape-worms. The case of ascaris in the pig has been further considered. Two series of experiments seem to show that in the presence of Vitamin A a far heavier infestation results. This is contrary to the generally accepted opinion. It has been found difficult to infest pigs with ascaris a second time, though it is not clear if this immunity is due to age or to the effect of the earlier infestation.

Parasites of economic plants and weeds.—On the plant side, considerable attention has again been devoted to the helminths associated with potato diseases. Since 1927 intensive study has been carried out on field plots at Winches Farm on the stem

eelworm (*Tylenchus dipsaci*) on potato tubers. It has been demonstrated that the principal varieties of potatoes in commercial cultivation are equally susceptible. During the present season these plots have been used to test the susceptibility of other crops to attack by the potato strain of this parasite. The " oats " strain of *Tylenchus dipsaci* which causes " tulip " root was established at Winches with infected soil from Aberdeen in 1928, but not until this season when the seed was sown in the autumn did the " tulip " root become marked. Efforts will now be made to test the effect of crop rotations in controlling the infection and to determine the role of weeds in carrying on the parasite in the absence of oats. An account of a new gall disease on fine bent-grasses which was discovered on Winches Farm has been published (3). A new eelworm disease causing serious losses in violets in Devon has been investigated.

Investigations have been continued on the effect of root secretions of various grasses in controlling *Heterodera Schachtii* which, like *Tylenchus dipsaci*, is a serious menace to the potato growing industry.

Parasites of insect pests.—In last year's Report the interesting problem of the control of insect pests of agricultural crops by means of helminth parasites was fully discussed. An account of the work on the eelworm parasite of flea beetles has now been published (5).

Titles of papers issued during the year.

1. Clapham, P. A.: On the prophylactic action of Vitamin A in helminthiasis. *J. Helminth.*, **11**, 1, 9-24, 1933.
2. ————: On the life-history of *Heterakis gallinae*. *Ibid.*, **11**, 2, 67-86, 1933.
3. Goodey, T.: *Anguillulina graminophila* n.sp., a nematode causing galls on the leaves on fine bent-grass. *Ibid.*, **11**, 1, 45-56, 1933.
4. Morgan, D. O.: The effect of heavy stocking on the worm burden under a system of rotational grazing. *Ibid.*, **11**, 3, 169-180, 1933.
5. Oldham, J. N.: On *Howardula phyllotretae* n. sp., a nematode parasite of flea beetles (*Chrysomelidae; Coleoptera*), with some observations on its incidence. *Ibid.*, **11**, 3, 119-136, 1933.

23. DIVISION OF HELMINTHOLOGY, DEPARTMENT OF ZOOLOGY, UNIVERSITY OF EDINBURGH.

As the post of Lecturer in Helminthology was vacant from 1st January to 30th September, 1933, much of the research work was suspended.

Three papers on parasitic worms were published (1, 2, 3). The first of these papers is important as it contains the results of the first systematic survey of the parasitic worms which occur in the wild mammals of Scotland. In general the paper provides in-

formation of considerable interest in comparative parasitology. The second and third papers record the parasitic worms found during the examination of the alimentary tract of fowls, ducks and pigeons.

Titles of papers issued during the year.

1. Cameron, T. W. M., and Parnell, I. W.: The internal parasites of land mammals in Scotland. *Proc. Roy. Physical Soc.*, **22**, 3, 1933.
2. Foggie, A.: A note on helminth parasites of poultry. *Scott. Nat.*, March-April, 1933.
3. ———: On a cestode parasite of the domestic pigeon (*Columba livia*). *Ann. and Mag. Nat. Hist.*, **12**, 10, August, 1933.

F

ANIMAL PATHOLOGY

24. RESEARCH INSTITUTE IN ANIMAL PATHOLOGY, ROYAL VETERINARY COLLEGE.

Mastitis in Bovine Animals.

Control.—One of the main objects of the work on mastitis since 1929 has been to see to what extent it is possible to control the disease by the policy of milking infected cows last. This investigation has been proceeding in 7 almost self-contained herds comprising at the start some 550 cows. One of these herds appears to have been free from the streptococcus which causes the common chronic form of the disease since July, 1932, a result attributed largely to extensive selling of infected cows. In a second herd clinical cases have not been seen for 2 years, although some cows still harbour mastitis streptococci in their milk irregularly and in small numbers. An account has recently been published (1) of a third herd, of which 12 (20 per cent.) were infected, which we believe illustrates for the first time indisputably that it is possible to build up and maintain for a sufficiently long period a group of cows whose milk is free from the common mastitis streptococcus. Their freedom in this respect has been proved by cultural examination of the milk of every cow at intervals of three to five months for the past three-and-a-half years. The observations in this herd are considered to be of great practical importance because they demonstrate that chronic streptococcus mastitis is a strictly contagious disease and is, therefore, theoretically preventable. This herd is also important in another respect, namely, that it has enabled a close study to be made of other forms of mastitis to which cows are subject.

Contagious Bovine Abortion (Brucella Infection).

Relationship between bacteria of the Brucella and Pasteurella groups.—This question arose in connection with a suggestion that the so-called " Brucella disease of the fowl " is due not to Brucella infection but to infection with bacteria of the Pasteurella group which are known to occur commonly in poultry. The experiments offered no support for the supposed relationship between these two bacterial groups, but conversely they favoured the view that fowls may sometimes harbour Brucella organisms (2).

The incidence of contagious abortion in cattle.—The testing of cows belonging to 7 herds by the blood agglutination reaction has

given the following results. Of 614 animals tested, 152 (24·7 per cent.) were positive, 53 (8·7 per cent.) were doubtful and 409 (66·6 per cent.) were negative. The highest and lowest herd incidence of positive reactors was 48 per cent. and 4 per cent. respectively, and no herd was free from the disease. The incidence given is that found at the first blood test; within 18 months prior to this no vaccinations had been carried out.

As a corollary, a number of blood samples have been collected from cattle at an abattoir. Out of 100 cow-blood sera, 21 (21 per cent.) reacted positively. Out of 213 blood samples from male cattle (steers), 7 (3 per cent.) reacted positively.

The incidence of Brucella infection in specimens other than bovine.—Blood samples from swine and sheep have been obtained from an abattoir and tested by the agglutination reaction test. Samples from 517 swine and 348 sheep were collected, but no indication of infection in these species was found.

Blood samples from 255 horses at an abattoir and from 264 horses belonging to the Army have been examined. Tests of the 519 samples gave results indicative of infection in 20 (3·9 per cent.), while 26 (5 per cent.) were doubtful.

Johne's Disease in Cattle.

An experiment of a preliminary nature was carried out on 10 cattle by this Institute in collaboration with the National Institute for Medical Research, the Institute of Animal Pathology, Cambridge, and the Department of Veterinary Pathology, Liverpool. The object of the experiment was to compare the effects of certain kinds of Johnin available in this country.

Avian Tuberculosis in Cattle in Great Britain.

Prior to this work, only one instance of natural avian tuberculosis in cattle has been reported in this country. Arising out of field work on Johne's disease, three herds were found to contain cattle, mostly calves, infected with avian tuberculosis (3). In two of the herds tuberculosis was proved to exist among the fowls and these had free access to the cattle.

Avian tuberculosis in cattle is retrogressive in its character; it is, therefore, of little importance on its own account. Unfortunately, however, animals infected with avian tuberculosis react to Johnin and slightly to tuberculin, although they are free from Johne's disease and bovine tuberculosis and, as the present investigations showed, they may continue to react during adult life. Two animals continued to give strong reactions to Johnin for a period of 6 months after removal from the source of infection.

The opportunity was taken to study the virulence of the avian strains isolated from 5 of the cattle.

Titles of papers issued during the year.

1. Minett, F. C., Stableforth, A. W., and Edwards, S. J.: Studies on bovine mastitis. VIII. The control of chronic streptococcus mastitis. *J. Comp. Path. and Therap.*, **46**, 133-138, 1933.
2. Priestley, F. W.: The absence of serological relationship between Brucella and Pasteurella organisms. *Ibid.*, **46**, 38-41, 1933.
3. Minett, F. C.: Avian tuberculosis in cattle in Great Britain. *Ibid.*, **45**, 317-330, 1932.
4. ————: Johne's disease, including Johne's disease in sheep. *Address: Nat. Vet. Med. Assoc. Cong.*, Sept., 1933.
5. Stableforth, A. W.: Nature and control of mastitis. *Farmer and Stockbreeder*, **47**, 2254, 1933.

25. INSTITUTE OF ANIMAL PATHOLOGY, CAMBRIDGE UNIVERSITY.

Filterable Viruses.

Contagious pustular dermatitis of sheep and goats (1).—Seventeen strains of the virus have been examined by cross-immunity experiments. With the exception of five which were inert, all the strains, which included several from abroad, have resembled the standard virus. The possibility of determining the nature of suspected material by a complement fixation test has been confirmed and should be of value in demonstrating the existence of the disease in field outbreaks. It has also been shown that neutralising antibodies are present in the sera of recovered and hyperimmunised lambs.

Infectious ophthalmia of lambs.—A preliminary investigation into this seasonal disease of lambs has shown that the infection can be transmitted from affected to healthy lambs. The actual causal agent has not yet been definitely determined but the evidence now available suggests that it is a virus. It is hoped to complete the investigation during the coming lambing season.

Fowl paralysis.—A survey of this disease as it occurs in the eastern counties is in progress and material from a considerable number of outbreaks has been examined. A preliminary experiment on the transmission of the disease has been completed. In a total of 44 birds inoculated with tissues from affected fowls 8 cases of the disease developed. A number of control uninoculated birds from the same source remained unaffected. So far attempts to secure serial transmissions of the disease have failed but further experiments are being undertaken in connexion with this aspect of the problem. Haematological examinations have also been carried out and studies have been made of the variations which may occur in the cellular content of the blood in normal fowls. While final results have not yet been obtained, it has been found that enormous fluctuations occur in the polymorphonuclear cell count.

C. Welchii (2).—A study has been made of an anaerobic organism ("*B. ovitoxicus*") isolated by W. H. Bennetts from the intestinal tract of sheep in Western Australia and said to be the cause of "Pulpy Kidney" disease of sheep in that country. The relationship of "*B. ovitoxicus*" to the four known types of *C. Welchii* has been investigated. By means of cross-immunity experiments it has been shown that Bennetts' organism is identical with that isolated from sheep in this country and which has been designated *C. Welchii* (Type D).

A number of strains of *C. Welchii* obtained from outbreaks of anaerobic diseases of cattle and sheep has also been examined. All the strains have been found to belong to one or other of several types already described.

Salmonella infections.—The investigation into the production of a soluble toxin from the Salmonella group of organisms and, in particular, *Bact. abortus ovis* has been continued. A method of preparing a dried, stable endotoxin has been elaborated.

Fowl cholera.—Heavy losses amongst ducks in Norfolk were found to be due to fowl cholera. There was reason to suppose that the infection was introduced in imported geese and an investigation has been made of the prevalence of the disease in this area.

Diagnosis of Bacterium abortus ovis infection by agglutination (3).—Since *Bact. abortus ovis* is closely related antigenically to various other members of the Salmonella group, care must exercised in accepting the results of the agglutination test as evidence of the existence of infection by that organism. With a view to reducing the chances of error in this connexion a qualitative estimation has been made of the agglutinins present in the blood of a series of normal and affected animals. It was found that while "O" and "H" (type phase) agglutinins for *Bact. abortus ovis* were present in small amounts in the blood of a fairly high percentage of normal sheep, in animals which had recently aborted the titre for both types of agglutinins lay between 1/80 and 1/1280 and remained at a considerably higher level than the normal average after an interval of six months. It would appear that the presence of both "O" and "H" agglutinins at a titre of 1/80 and 1/160 respectively is consistent with a fairly recent infection with *Bact. abortus ovis*. Preliminary tests have shown that it may be possible, in some cases at least, to demonstrate the presence of agglutinins for a specific antigenic component of the organism in the group phase and the investigation of this aspect of the problem is being continued.

A defective condition of the bones of sheep in certain areas (4).—A dystrophic condition of the bones of sheep is recognised by

farmers in various parts of the North of England. It occurs in the poorer hill pastures and is seen mainly in young animals of about four months old and upwards. The condition is associated with general unthriftiness leading to emaciation accompanied by oedema which appears to result from heavy worm infestation together with poor quality of the available herbage. Analysis of a number of samples of the latter has shown it to be of low mineral content which leads to a diminution in the amount of the mineral constituents of the blood of affected animals. In particular the average level of the blood phosphorus is reduced and the bones are relatively poor in this element. The calcium/phosphorus ratio of the latter is high and that of ash/organic matter low. The appearance of the bones in advanced cases is that of extensive atrophy resulting from malnutrition. Histological changes such as may be expected to result from an actual phosphorus deficiency have not been observed but since material from cases in the earlier stages of the condition has yet to be examined it cannot be assumed that they do not occur.

Streptococci.—The examination of strains of streptococci isolated from the cervix uteri of barren mares has been continued but as the worker concerned has now left the Institute further investigation of their properties has had to be postponed for the time being.

Biochemistry.

Effects of nematode infestations on the metabolism of the host (5).—This work has been continued. Metabolism experiments have shown that the presence of heavy infestations of nematodes prevents the host digesting the protein of its ration to the full extent whilst the digestibility of the other nutritive components is apparently unaffected by the presence of the nematodes. It has also been shown that nematode infestations interfere with the calcium and phosphorus metabolism of the host but have no effect on the sodium or potassium metabolism. A substance was extracted from nematodes of sheep which was shown to inhibit the action of pepsin. It was concluded that this substance, called a nezyme, might be the cause of the impaired metabolism of the protein by the host.

Eclampsias of pregnancy in ewes.—An investigation was made during the Spring of 1933 into the occurrence of these diseases in Yorkshire. A survey was made of the pasture on farms where it occurred and blood and urine analyses were made of cases of the disease. More work is necessary before any definite conclusions can be drawn.

Defective condition of the bones of sheep "double scaup" or "Cappi."—A biochemical examination of this condition has been made from cases obtained in Yorkshire and Northumberland.

Pasture, blood and bone analyses were carried out and the investigation is being continued in an attempt to elucidate the factors causing this condition.

Lactation tetany (8).—The disease has been investigated in four districts. Three forms of the condition have been differentiated on clinical grounds and a biochemical examination has been made of body fluids of animals suffering from the acute, sub-acute and chronic stages of the disease. The main changes in the blood were found to consist of a slight fall in the calcium content and a large fall in the magnesium. The blood calcium returned to normal as the clinical symptoms of the disease disappeared but this was not the case with the blood magnesium which remained low even up to 36 days after. Ketosis was always found to be present during the course of the disease. The clinical appearance presented by animals suffering from the chronic form was identical with that observed in the condition known as "acetonaemia" in some districts. Histological and bacteriological examinations have also been made of animals which had died.

Analysis of the blood and bones of farm animals.—Standards for the normal composition of the blood and bones of farm animals which can be used by those interested in the bio-chemical aspects of animal pathology are being established.

Investigations into the effects of salivary secretion on metabolism (9).—The effects of salivary secretion on the mineral and nitrogen balances carried out in the course of metabolism work have been overlooked by most research workers. An investigation with sheep showed that salivary secretion can add to the food relatively large amounts of mineral and also organic constituents to such an extent as to affect materially digestibility coefficients and upset the ratios of the minerals in the food ingested by the animals.

Calcium metabolism of sheep.—This investigation was continued during 1932-33. It was found that calcium deficiency *per se* had little effect on the metabolism of the nutritive components of the ration and that several months on a calcium deficient ration was necessary before changes occurred in the calcium and phosphate content of the blood. Several ewes have been over 27 months on the ration, have been pregnant twice and given birth to live lambs, whilst others have had to be killed in the course of the investigation owing to poor condition. Little change was found in the mineral content of the bones of the animals killed in the course of the investigation.

Physiology of cellulose digestion.—This work has been continued chiefly with the view of ascertaining the physiological significance of a yellowish pigment which is formed in the course of cellulose destruction by bacteria.

Biological Products and Immunity.

Tuberculin (10).—The study of the dermal reactions of tuberculous and normal cattle to various fractions of tuberculin has been completed. It has been found that a tuberculin prepared in an improved synthetic medium and concentrated by the extraction of the active principle with ammonium sulphate has appreciably reduced the reactions in non-tuberculous cattle without impairing the specific principle. The different components of glycerine veal broth have been studied with reference to their ability to produce non-specific reactions.

In collaboration with a number of veterinarians, comparative trials with the new preparation and with " O.T." were undertaken under field conditions. The results embracing a total number of 915 animals have shown that the synthetic tuberculin will be of considerable value in facilitating the interpretation of " doubtful " reactions to the double intradermal test (11).

Johnin.—As a result of the information gained in the preparation of synthetic tuberculin, it has been possible to prepare a precipitated synthetic Johnin. This product which was tested under laboratory conditions and found to be of adequate potency presents a distinct advantage over Johnins as prepared hitherto, in that the non-specific response is very materially reduced. This Johnin has been applied on a small scale to infected herds with encouraging results (12).

Complement.—The experiments on the preservation of complement have been completed and a satisfactory method of maintaining its potency for several weeks has been devised (13).

Vaccination of calves against tuberculosis with B.C.G. vaccine.—A continuation of the experiments on the duration of immunity in calves vaccinated by the intravenous route and tested at varying intervals by the oral administration of virulent cultures has confirmed the previous observation that calves are completely immune three months after vaccination.

It has been further shown that an increase in the period elapsing between vaccination and the administration of the test dose results in a progressive diminution in the degree of resistance to infection by the mouth. Thus at six months after the protective dose, the immunity was nearly complete, at nine months 60 per cent. of the calves were resistant, while at 12 months only one animal out of seven possessed an absolute immunity. It was noted ,however, that where lesions were found in vaccinated animals, they were generally more discrete than those in the controls and often presented evidence of retrogression.

The experiments on the possibility of reinforcing a waning immunity with further doses of vaccine have not yet been completed.

Parasitology.

Work upon the larval stages of parasitic nematodes has continued along the lines indicated in a previous report.

An attempt has been made to discover the factors usually controlling the ecdysis which the larvae must undergo before they can infect the host. The evidence obtained suggests that it will be possible to explain this ecdysis, and perhaps also the ecdysis of the later larval stages, in terms of physical and chemical factors normally present in their environment (14). This work has suggested that it may be possible to kill large numbers of infective larvae on pastures by chemicals that will not seriously injure the pastures, and experiments are being undertaken to investigate the possibility of thus reducing the nematode infestations of considerable areas of pasture land.

The possibility that nematode larvae may transmit pathogenic bacteria to their hosts by ingesting these before they become infective larvae and ejecting them after they have undergone, inside the host, the second ecdysis, is being investigated.

A study has been made of the coccidia obtained from a large number of fowls affected with these parasites with a view to determining the varieties responsible for fowl coccidiosis in this country as well as the nature and extent of the lesions caused by each variety. So far as this work has gone there seems to be no doubt that *Eimeria tenella* is the species responsible for acute coccidiosis accompanied by many deaths in young chickens, and that a very similar species, probably *E. necatrix*, causes a severe inflammation of the small intestine in rather older birds.

E. acervulina is also frequently found in the small intestine often in very heavy infestations, but this species does not penetrate deeply into the mucous membrane. *E. maxima* is fairly common but has not been found to cause very extensive lesions.

Certain parasites hitherto unknown in domestic birds have been identified, viz., *Davainea tetraoensis* (Fuhrman) in the turkey which had previously only been described in the capercailzie in Switzerland and some small flukes of the genus *Levinecella* in a duck from Norfolk.

The study of the life history of a filariid nematode found in the skin of horses associated with cases of fistulous withers and " poll evil " has been completed (15). A similar nematode of the genus *Onchocerca* has been observed in cattle in the ligamentum nuchae and in the gastro-splenic fascia. The parasite in the former situation has hitherto only been found in Australia and North Africa. It has been ascertained that *Simulium ornatum* is the vector fly in this case and an attempt is being made to work out the life history of the parasite.

Botany.

Ranunculaceae.—The investigation into the toxic principle of the N.O. *Ranunculaceae* has been continued. The first substance to be obtained in a pure state from these plants was anemonin. This is a white, crystalline, non-irritant body which various authors have considered to be the toxic principle of buttercups. On intravenous injection, it causes convulsions, depression of the respirations, a fall of blood pressure and slowing of the heart beat. Since it soon became apparent that anemonin does not occur in the living plant, attention was directed to its precursor proto-anemonin. This substance is a highly irritant oil. External application of a minute quantity produces a painful blister which heals slowly. Given by the mouth, it causes severe inflammation of the gastro-intestinal tract. On intravenous injection it produces a marked rise in blood pressure from stimulation of the smooth muscle of the blood vessels. The substance, however, is comparatively non-toxic when given intravenously and its external action may be prevented by the immediate application of a solution of potassium permanganate. When improved methods were used for the extraction of proto-anemonin from buttercups, it became doubtful if this substance occurs as such in the plants. It is now considered probable that a substance closely related to proto-anemonin is the toxic principle present in fresh buttercups. This substance was found to possess an action very similar to that of proto-anemonin but it is a much more stable product.

According to the literature, *R. sceleratus* is the most toxic of the buttercups. However, apart from the irritant oil, the only other toxic substances present appear to be organic acids. These cause convulsions and death from depression of the higher centres.

Bracken.—An investigation into the toxicity of bracken has been undertaken. This plant is toxic in both the fresh and dried state. Death results in about 14 days and definite post-mortem changes are seen. A base and an acid have been isolated. Both are toxic and their physiological actions are at present being examined. The toxic principle is cumulative and is excreted very slowly from the body.

Preliminary feeding experiments have been carried out with members of the N.O. *Cruciferae* and *Euphorbiaceae*. Crude substances obtained from some of the plants have also been examined.

Eradication of weeds poisonous to livestock (17).—Experiments carried out on a small scale confirm the usefulness of chlorates in the eradication of poisonous plants from pastures without seriously damaging the grasses of the pasture. A 3 per cent. spray was found to be the most efficient for *Ranunculus repens*. Large scale experiments will be necessary before it can be recommended as a practical method for stockfeeders. The results of such experiments will be seen in the spring of 1934.

Titles of papers issued during the year.

1. Glover, R. E.: Contagious pustular dermatitis. *3rd Rep. Direct. Inst. Anim. Path. Camb.* (1933-34), 1, 1934.
2. Wilsdon, A. J.: The relationship of *Bacillus ovitoxicus* (Bennetts) to the *C. Welchii* group. *Ibid.*, 46, 1934.
3. Bosworth, T. J.: The diagnosis of *Bacterium abortus ovis* infection by agglutination. *Ibid.*, 19, 1934.
4. Bosworth, T. J., and Stewart, J.: A defective condition of the bones of sheep in certain areas. *Ibid.*, 33, 1934.
5. Stewart, J.: The effects of nematode infestations on the metabolism of the host. Part I. *Ibid.*, 58, 1934.
6. ————: The effects of nematode infestations on the metabolism of the host. Part II. *Ibid.*, 77, 1934.
7. Shearer, G. D., and Stewart, J.: The effects of nematode infestations on the metabolism of the host. Part III. *Ibid.*, 87, 1934.
8. Blakemore, F., and Stewart, J.: Some observations on several outbreaks of so-called lactation tetany in cattle. *Ibid.*, 159, 1934.
9. Franklin, M. C.: The importance of assessing the effects of salivary secretion in the interpretation of the results of metabolism and mineral balance experiments. *Ibid.*, 135, 1934.
10. Glover, R. E.: A study on tuberculin with special reference to the double intradermal test. *Ibid.*, 200, 1934.
11. Buxton, J. B., and Glover, R. E.: Comparative field trials of a synthetic and a standard tuberculin. *Ibid.*, 227, 1934.
12. Glover, R. E.: The preparation of a synthetic Johnin. *Ibid.*, 233, 1934.
13. ————: A note on the preservation of complement. *Ibid.*, 52, 1934.
14. Lapage, G.: The cultivation of infective nematode larvae on cultures of *B. coli*. *Ibid.*, 237, 1934.
15. Steward, J. S.: *Onchocerca Cervicalis* (Railliet & Henry 1910) and its development in *Culicoides nubeculosus* Mg. *Ibid.*, 272, 1934.
16. ————: The occurrence of *Onchocerca cervicalis* in cases of fistulous withers and poll evil. *Ibid.*, 285, 1934.
17. Stewart, J., and Wright, C. W. B.: A preliminary note on the eradication from pastures of some plants poisonous to livestock. *Ibid.*, 298, 1934.

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26. VETERINARY LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

FOOT-AND-MOUTH DISEASE EXPERIMENTAL STATION, PIRBRIGHT.

(Under the general direction of the Foot-and-Mouth Disease Research Committee.)

The investigation of the strains of virus encountered in the field during the past three years has shown the question of the immunological types of the virus to be more complex and difficult than was supposed. In order to continue the study of the different types, in the larger animals, it was necessary to expand the station and to provide improved facilities for isolating different groups of experiments. Extensive measures of reconstruction were therefore undertaken, and the work with the larger animals was necessarily interrupted and greatly curtailed.

During the year several strains of virus received from the field were found to belong to the " A " type; this type had not been encountered in Britain since 1925.

An observation of some importance, in connection with foot-and-mouth disease investigations, was the demonstration of discrepancies between the results of " typing " work in guinea pigs and cattle respectively. This matter is being further investigated.

Veterinary Laboratory, Weybridge.

Babesiasis and Anaplasmosis.—The African and South American strains were maintained, and three pedigree animals were immunised for export to Brazil and Southern Rhodesia.

Attempts were made to transmit anaplasmosis by biting-flies. One susceptible animal received 46 bites of flies of the species *Haematopota pluvialis* which, immediately before, had bitten an infected animal in the acute stage of anaplasmosis. Another susceptible animal received over 6,000 bites of *Stomoxys calcitrans* in the same way, but in neither instance was transmission effected.

Contagious abortion of cattle.—During the year 23,581 doses of the living vaccine were prepared and issued, and 1,491 agglutination tests were performed in connection with vaccination or attempts at eradication of the disease.

1964 bovine blood samples have been tested for the presence of *brucella* agglutinins under the Agricultural Research Council's experimental eradication scheme.

The investigation of the distribution of *Brucella abortus* in the body of the " carrier " cow was continued, and will shortly be concluded. Observations were continued on the occurrence of different strains of *Br. abortus*, with particular reference to their virulence and antigenic properties. Further work was carried out on the value as vaccines of cultures killed or modified in various ways, and certain killed vaccines were issued on a small scale for trial in the field.

Particular attention was paid to *Brucella* infections in animals other than bovines. An examination for the presence of *Brucella* agglutinins was made of 10,000 samples of pig's blood, obtained from various parts of Great Britain. A report on this work has been published in a technical journal.

The results were as follows :—

> Samples of blood from 10,474 sows have been submitted to the agglutination test for the presence of *Brucella* agglutinins.
>
> Four bloods gave positive reactions in dilutions of 1/25, seventeen bloods positive reactions in dilutions of 1/50, and four bloods positive reactions in dilutions of 1/100.
>
> Positive reactions in dilutions of 1/100 are generaly regarded as indicating existing or recent infection with *Brucella suis*.

Confirmation was obtained of the fact, previously reported by workers in other countries, that *Br. abortus* may occur in pure

culture in the contents of certain forms of abscess in the horse (3). During the year veterinary practitioners sent in a considerable number of samples of pus from unopened cases of "poll-evil" and "fistulous withers." In approximately three-quarters of the cases, *Br. abortus* was isolated from the material, and in the majority of instances both the blood-serum and the fluid from the abscess contained specific agglutinins. This work is being continued, and trials are being made of the effect of a vaccine on affected horses. A search has also been commenced for evidence of infection in dogs and cats.

Tuberculosis.

Bovine.—During the year 1,392 doses of B.C.G. vaccine were prepared and issued for trial in selected herds. An experiment was carried out to test the extent to which guinea pigs will contract tuberculosis when exposed to contact with infected (inoculated) guinea pigs. Some workers have stated that transmission of the infection by contact rarely or never occurs in these animals, and the matter is one of some importance in connection with laboratory work on the B.C.G. vaccine. Of 12 guinea pigs in contact with others that had been inoculated subcutaneously with tubercle bacilli, 8 died of tuberculosis; of 12 animals in contact with others that had been inoculated intraperitoneally, 4 died of tuberculosis. No disease occurred in 12 guinea pigs exposed to indirect infection, without actual contact (4).

Avian.—An investigation of the protective value of B.C.G. (avian strain) against artificial and natural infection is still in progress.

Lactation tetany in cows.—The occurrence of this disease was investigated in Herefordshire and neighbouring counties, and arrangements were made with local veterinarians to send blood samples from suspected cases for confirmation of the diagnosis by determination of blood magnesium. An information schedule, giving case history and treatment adopted, accompanied each sample. Hypomagnesaemia is the most characteristic feature of the blood picture, and intravenous or subcutaneous injections of magnesium salts appear to constitute a useful therapeutic measure. The pastures on which the disease occurs are not deficient in magnesium, and no question of dietary deficiency of this element arises, so that the observed hypomagnesaemia is a symptom rather than a cause. The actual cause is obscure, but evidence to date suggests endocrine disturbance. Experiments have also been carried out on the fate of injected magnesium salts and the rate of disappearance from the blood stream, with the object of improving therapeutic treatment of the disease; also on the normal level of blood magnesium, with the object of establishing a basis for diagnosis.

Swine fever.—The work on the survival of the virus in carcases, and on the effect of pickling and smoking, was concluded (5). The

results were as follows :—(i) The virus of swine fever survived 73 days (not end-point) in the bone marrow of "salted" and "chilled" carcases; (ii) the virus survived 17 days in the skin and muscle of pigs killed before the appearance of clinical symptoms. There was some evidence that virus was still present in salted muscle after 73 days; (iii) the virus survived 42 days in salted skin and muscle of pigs killed after the appearance of clinical symptoms; and (iv) the virus survived for 37 days (not end-point) in bone marrow and muscle, and for 19 days in skin, of smoked carcases.

Parasitic gastritis.

(a) *Immunity Experiments.*—Material collected during the course of the 1932 field investigation into immunity of lambs to this disease has been worked over, and the following conclusions arrived at :—(i) Lambs are capable of acquiring an immunity to parasitic gastritis, powerful enough to protect them against a rate of infection at pasture which is sufficiently great to cause the death of unprotected lambs in less than seven weeks; (ii) the immunity operates against the acquisition of infection, and also in enabling the lambs to resist the injurious effects of the infestation already present. Resistant animals may actually carry more parasites than are carried by non-resistant animals at the time when they succumb to the disease; (iii) the immunity is acquired slowly and appears to require about 18 weeks to become firmly established. A gradually acquired infection leads to immunity, while a quickly acquired infection leads to death, where the final number of parasites is the same in each instance; (iv) the immunity is specific and operates more powerfully against *Nematodirus* and *Haemonchus* than against *Ostertagia*, *Trichostrongylus* and *Coperia;* and (v) the immunity has an inhibitory influence on the development of young worms—seen particularly clearly in *Nematodirus.* Egg laying by the worms in resistant animals may be reduced to one-thirteenth of the number produced by worms in non-resistant animals.

(b) *Observations on epidemiology.*—Detailed enquiries have been made into the epidemiological reasons underlying outbreaks of parasitic gastritis as they naturally occur on farms. These have led to the following conclusions :—(i) There are two epidemiological types of parasitic gastritis. Where pathogenic infestation is acquired from a residue of infective larvae present on the land, and where pathogenic infestation is acquired as a result of autoinfestation; (ii) the development of severe ostertagiasis may result from residual soil infestation alone, in as short a time as four weeks; (iii) the development of severe haemonchosis may result from autoinfestation alone, on clean arable land, in as short a time as seven weeks. (The two occurrences are probably not restricted to the two kinds of parasite actually concerned in the observations); (iv)

the residue of infective larvae where sheep have been penned over a field may be very different in different parts of the field; (v) lambs up to seven weeks old are not susceptible to haemonchosis under natural farming conditions; (vi) lambs as young as 9 or 10 weeks old may suffer from severe ostertagiasis under farming conditions; (vii) conditions on arable land may be so favourable for larval development that even the relatively small number of eggs disseminated by ewes may be sufficient to leave a dangerous infection in the soil after once penning over; (viii) six days is sufficient (under optimum weather conditions) for the mass development of infective larvae under actual field conditions; and (ix) there is an enormous difference between the suitability of various field conditions for larval development. The risk of pathogenic infection is much greater on arable land than on permanent pasture.

Fascioliasis.—Curious malformed trematode's eggs, found in the gall bladder of a sheep were traced to immature specimens of *Fasciola hepatica* in the liver. To all appearances these young flukes were normal, and it is considered probable that the production of malformed eggs is a normal occurrence in the early stages of the activity of the generative organs of the liver fluke. The finding of these eggs in the faeces may at times be of some clinical value, as an indication of the period at which infestation has been acquired by an animal.

A histological examination of these worms confirmed the observations of previous investigators that the shell substance originates in the vitelline cells and not in the shell gland.

Syngamiasis.—Work on the association of earthworms to gapes in chickens has been continued and evidence obtained that the gapeworm larvae can retain their infectivity in the earthworm for three years and one month. Any part of the length of the earthworm is capable of carrying the larvae. A number of thick walled cysts were recovered by digestion from infected earthworms; some of the cysts contained what appeared to be living gapeworm larvae and others, more or less completely disintegrated larvae: it is probable that they are formed in the muscular tissue of the earthworm. An instance was observed of a single naturally infected earthworm, fed to a chicken, resulting in the development of 24 pairs of gapeworms. These observations strongly suggest that earthworms are of great importance in syngamiasis, in collecting gapeworm larvae from the soil and storing them, in protecting them from adverse conditions of cold and dryness, and in conveying them to the chick.

Davainiasis in chickens.—Snails of four different species, infected with the cysticercoids of *Davainea proglottina* were fed, in different proportions, to 10-weeks old chickens; other chickens of the same hatch being reserved as controls. The chickens were weighed weekly throughout the course of the experiment and a count made of the worms recovered at *post-mortem* examination. No correlation could, however, be found between the weights of the chickens

and the extent of parasitism, and it was concluded that the infection of 3,000 or 4,000 of these worms (which was found to be present in some of the fowls) is not sufficiently high to cause noticeable disturbances of health. Observations since made have shown that an infestation heavier than 3,000 to 4,000 of these worms frequently occurs under poultry-farming conditions (6).

Blackhead in turkeys.—A study has been made of the fate of arsenic in the body of the turkey, with the object of ascertaining how far carcases of turkeys treated with neosalvarsan are likely to exceed the limits for arsenic in food, laid down by the Royal Commission of 1903. It has been found that intravenously injected neosalvarsan is eliminated in the excreta of turkeys so rapidly that the important edible tissues, with the exception of the liver, are down to the permissible figure (1·4 parts per million) in about 3 days after therapeutic dosing; and that the total arsenic left in selective tissues such as the liver is then too small to be a source of serious criticism. When a course of repeated daily injections is practised, the carcase is technically marketable about a week after the last dose.

Fowl pox.—The pigeon-pox vaccine has been employed on a large scale, and during the year 427,356 doses were prepared and issued for use in the field. Many samples have been dispatched overseas, under conditions of cold storage, to various parts of the Empire In most cases the vaccine has been active on arrival and has given a useful protection against the disease.

The reports of the value of the vaccine in the field at home have in general been excellent. A few reported cases of failure to arrest the spread of the disease have shown, on investigation, an omission to remove active cases of the disease from the flock at the time of the inoculation.

Pheasant pox.—Further work has been carried out in connection with an outbreak of pox in pheasants. It has been found that the pigeon-pox vaccine confers on pheasants a considerable protection against artificial infection.

Fowl typhoid.—Many outbreaks of this disease have again been diagnosed during the year, and 14,590 doses of vaccine were issued for use in infected flocks. The results of the vaccination were again reported to be satisfactory.

Salmonella infections in ducks.—In several outbreaks of disease in young ducklings *B.aertrycke* infection has been diagnosed, and eggs from carrier birds have been found to contain the causal organism. Ducklings hatched from eggs laid by carrier ducks have shown the organism in the yolk sac and the liver. This investigation is still in progress.

Newcastle disease.—Virus was obtained from one outbreak of the disease during the year. This solitary outbreak had some unusual features, and although the losses on the farm were severe, the virus lost its potency very rapidly. Investigations are being continued.

Diseases due to mineral deficiency.—Certain work has been carried out in loose association with observers in other parts of England and of the world. A paper on the osteodystrophic diseases of herbivora was published in France (15).

Titles of papers issued during the year.

1. Andrews, W. H.: Vaccination against bovine contagious abortion and the relation of this disease to undulant fever of man. N.V.M.A. Congress, Llandudno. *Vet. Rec.*, **13**, 1015-1020, Oct. 14, 1933.
2. Doyle, T. M.: Bovine contagious abortion. *J. Min. Agric.*, **40**, 491-505, 1933.
3. Duff, H. M.: *Brucella abortus* in the horse. *J. Comp. Path. and Thera.*, **46**, 1, 42-46, 1933.
4. Doyle, T. M.: The transmission of tuberculosis by contract from infected to healthy guinea pigs, with reference to some recent work on B.C.G. vaccine. *Vet. J.*, **89**, 30-34, 1933.
5. ————: The viability of the virus of swine fever in bone-marrow, muscle and skin of preserved carcases. *J. Comp. Path. and Thera.*, **47**, 1, 25-37, 1933.
6. Taylor, E. L.: *Davainea proglottina* and disease in fowls. The pathogenicity of the common poultry parasites: An unknown factor in the causation of disease. *Proc. 5th World's Poult. Cong. Rome*, 1933.
7. ————: The control of red-worms in horses. *Vet. Rec.*, **13**, 399-405, 1933.
8. ————: Notes on worms in foxes. *Vet. J.*, **89**, 20-23, 1933.
9. ————: The longevity of parasitic worms. *Vet. Rec.*, **13**, May, 1933.
10. ————: Notes on ascaris and lungworms in pigs. *Vet. J.*, **88**, 438-441, 1932.
11. Doyle, T. M.: The virus diseases of animals with special reference to those of poultry. *J. Comp. Path. and Thera.*, **46**, 90-107, 1933.
12. Dobson, N.: The diseases of poultry, rabbits and game, and their post-mortem inspections. *J. Roy. San. Inst.*, **54**, 4, 204-213, 1933.
13. ————: The relationship of poultry diseases to the practitioner, N.V.M.A. Congress, Llandudno. *Vet. Rec.*, **13**, 48, 1282-1295, 1933.
14. ————: Poultry diseases. *Ibid.*, **13**, 17, 373-380, 1933.
15. Green, H. H. with Theiler, Sir A.: L'Aphosphorose des herbivores. *Bull. Acad. Vét.*, **6**, 7, 1933.

27. ANIMAL DISEASES RESEARCH ASSOCIATION, EDINBURGH.

Tick-Borne Fever (3).—There is now very strong evidence that the cytoplasmic inclusions, which occur principally in the polymorphonuclear cells of the blood and spleen of cases of tick-borne fever, represent the specific causal organism of that disease.

A study of the developmental changes exhibited by the cytoplasmic inclusions and of the tissue reactions associated with their presence in the body is in progress.

There is yet no evidence that the causal factor of the disease is, at any stage of its development, filtrable.

It has been found that ticks are infective almost as soon after moulting as they are able to attach. The evidence suggests that infection is actually transmitted between the 24th and 48th hour

after attachment. It has not, so far, been found possible to infect sheep by infesting them with larvae bred from infective females, and thus it would appear that the infection cannot pass through the egg of the tick. As previously reported, females may remain infective for a period of at least fourteen months. It has been found that infected nymphs engorged upon healthy sheep are still capable, as adults, of producing the disease, but there is evidence which suggests that infected nymphs cleanse themselves of infection by feeding on non-susceptible hosts—guinea-pigs.

Ecology and distribution of Ixodes ricinus (4).—With the object of eventually obtaining means by which *Ixodes ricinus* can be effectively controlled, the ecology of the tick has been extensively studied during the last four years.

As a result of systematic enquiry, the distribution of *Ixodes ricinus* has been found to include the Border Uplands, Central Grampians, Argyllshire, the hilly districts of the north, and particularly north-west, Scotland.

Distribution of tick-borne fever.—The disease has, so far, been definitely diagnosed in the Newcastleton district, South Ayrshire, Argyllshire and Perthshire, but there is strong evidence that tick-borne fever is present on the hilly country of Scotland wherever ticks are prevalent.

Louping-Ill.—A dead vaccine prepared from formalinised brain and cord has been extensively tested in the field. Approximately 18,500 lambs and hoggs were vaccinated; 19,800 lambs and hoggs on the same farms were used as controls. It has been found that this vaccine is capable of effecting a very considerable reduction in the louping-ill incidence, but further experience of its use in the field is required before vaccination can be adopted as a routine prophylactic procedure.

Braxy.—Further field experience of the preventive value of formalinised whole culture *Vibrion septique* vaccine has been satisfactory. In a controlled field experiment in which 19,328 hoggs were vaccinated, the braxy mortality represented 0·75 per cent. In the controls, 12,195 in number, the mortality reached 7·33 per cent. These results are in close accord with those previously obtained, and there is reason to believe that the hitherto serious losses from braxy can now be effectively controlled.

Scrapie.—Histological and biochemical study of the changes which occur in the thyroid and adrenal glands in scrapie is being continued.

During the last twelve months a series of observations has been made on the comparative standard metabolic rates of scrapie and of normal sheep. There appears to be no significant difference between the metabolic rate of the scrapie sheep as compared with the controls.

The field experiment designed to test the possibility that the contagion of scrapie may be mediate through the medium of the grazings is being continued.

Grass sickness.—The Vitamin A content of the livers of numerous acute cases of grass sickness has been estimated, the controls being represented by the livers of normal horses immediately after slaughter. It was found that there was no significant difference between the vitamin content of the affected and control cases.

Systematic histological examination has been made of the vagi and peripheral nerves in acute cases of grass sickness. A large proportion of these nerves showed changes suggestive of degeneration, but similar appearances could be observed in the nerves of normal control horses.

Further attempts to reproduce the disease have been made. Quantities varying from 1 to 4 litres of citrated blood obtained from acute cases of grass sickness have been injected intravenously into test horses, with negative result.

The stomach and bowel contents of acute cases of the disease have also been administered *per os* to test horses without appreciable effect. Filtered stomach and bowel contents, when injected intravenously, have, however, induced intense systemic reactions, and a study of the toxins contained in such filtrates and of the anaerobic bacterial flora from acute cases of the disease is proceeding.

Contagious bovine abortion.—The scheme of research, which has as its ultimate object the development of effective immunogenic methods, is progressing.

Enzootic abortion in ewes.—As previously reported, the results of two field experiments in which phosphates were fed in the form of wheat bran and bone meal showed that while such treatment succeeded in raising the blood phosphate concentration in cases of aphosphorosis, it had no appreciable influence in reducing the abortion rate.

During the past breeding season, Vitamins A, D and E, dissolved in oil and mixed with bran, were administered. This treatment was followed by a marked reduction in the abortion rate as compared with that of the controls, and the investigation will be repeated and extended.

Lactation tetany in cows.—Further examinations of blood from cases of lactation tetany confirmed our previous findings that the magnesium values are consistently low. Experiments have been carried out with a view to evaluating different methods of magnesium therapy. As a result a treatment has been devised, and several veterinary practitioners are collaborating in testing its therapeutic value.

Pine (2).—Further records of the occurrence of nutritional anaemia in sheep and young cattle have been received from various parts of the country, and the administration of iron has proved of specific value as a curative treatment for this condition.

Titles of papers issued during the year.

1. MacLeod, J.: A note on the use of derris against the sheep tick. *Scot. J. Agric.*, **16**, January, 1933.
2. Greig, J. R., Dryerre, H., Godden, W., Crichton, A., and Ogg, W. G.: Pine: A disease affecting sheep and young cattle. *Vet. J.*, **89**, 99, 1933.
3. MacLeod, J., and Gordon, W. S.: Studies in tick-borne fever of sheep. I. Transmission by the tick, *Ixodes ricinus*, with a description of the disease produced. *Parasit.*, **25**, 2, 1933.
4. MacLeod, J.: Control of the sheep tick on hill pastures. *Trans. H. and A. Soc.*, June, 1933.

28. VETERINARY RESEARCH DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Abortion.—Efforts are being made to protect cattle with a new type of dead vaccine. The chief feature of this vaccine is that it is grown on a medium containing unaltered uterine fluid, for two months. It is then stored in a dark cupboard for one month and formalised. After the addition of formalin it is stored in the refrigerator for one month at 2° C. before being used. Only recently isolated virulent cultures are used in the preparation of the vaccine. Two inoculations with this vaccine at an interval of one month in a small scale experiment protected laboratory animals from developing macroscopic lesions, whereas the dose of virulent organisms used, produced very obvious lesions in unvaccinated controls. The difficulty of securing herds where properly controlled experiments can be made, will delay the issuing of a report.

Fowl paralysis.—No further progress has been made in connection with this disease owing to the appearance of symptoms of paralysis among the control birds. This disturbing fact has thrown doubt on the success of transmission experiments referred to in the previous report. The exact relationship of intestinal parasites including oocysts to the type of fowl paralysis met with in Northern Ireland, would appear to be a subject for further investigation.

Bacillary white diarrhoea.—The blood testing scheme is continuing to give excellent results and efforts are now being made to establish a register of accredited farms. A considerable number of farms have qualified for entry to this register. Investigations into the technique of blood testing are being carried out and a paper on modifications of Beaudette's apparatus has been published (1).

Tuberculosis.—In the preliminary report (2) on the experiments with Spahlinger's anti-tuberculosis vaccine it is stated that the experimental animals would be slaughtered in 12 months. Owing to the excellent condition of the vaccinated animals, however, it was felt that the period of the experiment should be prolonged for a further 12 months. The heifers in the group have been mated with the object of submitting them to the strain of parturition and lactation.

General.—Many routine diagnostic investigations were conducted during the year. These reveal a serious increase in the incidence of coccidiosis in poultry, particularly in adults. Worm infestations are also giving rise to much loss.

Several outbreaks of swine erysipelas were investigated. On one farm where serious losses were occurring among sows, the use of anti-serum gave excellent results. An experiment to control these periodical outbreaks by immunising with vaccine and serum, is being conducted.

Titles of papers issued during the year.

1. Staff of the Veterinary Research Division. An apparatus for pipetting serum in making the agglutination test for the detection of carriers of bacillary white diarrhoea. *Vet. Rec.*, Oct. 7th, 1933.
2. Lamont, H. G., Kerr, W. R., and Shanks, P. L.: Report on experiments with Spahlinger's anti-tuberculosis vaccine. *Ibid.*, December 17th, 1932.

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ANIMAL NUTRITION AND ANIMAL BREEDING

29. ANIMAL NUTRITION RESEARCH INSTITUTE, CAMBRIDGE UNIVERSITY.

The chemistry of the plant in relation to the nutrition of the animal.—During the past year further progress has been made with investigations of changes occurring during growth in pure cultures of grasses, etc., and the relations between these changes and the varying nutritive properties of such produce. The scheme of investigations is new and, as would be expected, studies of the results led to further enquiry here and there in attempting to interpret them as satisfactorily as possible.

Apparently even when the greatest care is taken in obtaining specimens for examination from such growths there is great chance of contamination by soil. Lawn cutter specimens, especially if the growths are moist, are usually highly contaminated. In a few cases samples of very satisfactory appearance, from which very little soil could be separated either before or after drying in the unground state, were contaminated to the extent of confusing certain issues. Hand clipped specimens were found to be the best. It was found necessary to work out a way for determining as accurately as possible how far each specimen had been contaminated, and the importance of estimating on a soil-free basis will be illustrated. The faeces of sheep folded on a perennial rye-grass ley contained large quantities of soil.

Difficulty has been experienced in following carbohydrate changes when the amounts present are very small. A method correctly estimating even exceedingly small quantities, suitable for plant investigations, has reached the final testing stage. This process should prove very valuable in studying carbohydrate changes.

Continuous attention has been given to the following problems :—

(i) The different forms in which each class of foodstuff occur in grasses, and what disappears from the material in the digestive tract.

(ii) What sheep have removed from perennial rye grass.

(iii) The relative importance to the animal of the different kinds of digestion products in the same class.

(iv) Protein separation and hydrolysis, etc.

Pastures.—Dr. H. E. Woodman and his collaborators have continued their investigations into the nutritive value of pasture during the past year. With the publication of their paper on the nutritive properties of grassland under a system of cutting approximating to the conditions of rotational close-grazing with 5-weekly intervals of unchecked growth, they have brought to a conclusion one phase of these studies, namely, the influence of the intensity of grazing on the yield, composition and nutritive value of pasturage. They have been engaged on an investigation into the utilisation of young grass by swine, and the results of this work are now in the press. In collaboration with Mr. Oosthuizen, Dr. Woodman has also carried out an investigation into the value of pasturage for winter grazing, and an account of this work is now being prepared for publication. The investigations into the influence of intensive fertilising on the yield, composition and feeding value of permanent pasture have been continued, this work now having been prosecuted over a period of five seasons. Dr. Woodman and Dr. Evans have conjointly published a contribution to the vexed question of the capacity of pasturage to furnish sufficient cystine for purposes of wool growth in sheep subsisting wholly on grass.

During the past year, the results of the first of a series of investigations into the yield, composition and nutritive value of the lucerne crop have been published. The comprehensive study of this subject, in which the commercial aspects are being kept in mind, is being continued, and the problems of the effects of cutting lucerne at different stages of growth on yield, composition and feeding value and on the vigour of the plant; the leaf : stem ratio; and the composition and nutritive value of lucerne hay, lucerne meal and lucerne leaf meal, both for pigs and ruminants, are under investigation at the present time.

Dr. Woodman and Dr. Evans have worked out and published chemical methods for the quick determination of total, organic and inorganic sulphur in feeding stuffs and plant products. These methods should be of assistance to such workers as are engaged in sulphur metabolism, studies in farm animals or in investigating the question of wool growth in sheep. They have also carried out investigations into the possibility of the transformation of inorganic sulphur into cystine by bacterial agency, and although negative results were obtained, the investigation was necessary to test a hypothesis which had been put forward in connection with the utilisation of inorganic sulphur by sheep for purposes of wool-protein synthesis. Dr. Evans has further been engaged in the isolation of pure protein preparations from green lucerne, and the comparison of such proteins with those in standard feeding stuffs such as soya bean meal.

An investigation has recently been begun into the capacity for consumption, and the maintenance requirements, of sheep under conditions of both winter and summer feeding. The available data on these questions are so contradictory, that it is extremely difficult

to formulate reliable feeding standards for sheep. The carrying out of this programme of work will occupy several seasons.

Calorimetry.—Work on the fasting katabolism of various English breeds of pig has been continued throughout the year and is now nearing its close, only four of the twenty-five pigs remaining to be completed. Dr. Deighton is at present engaged on the first of a projected series of papers on this work which it is hoped will appear at intervals during the next year or two.

It is not proposed to begin any other line of experimental work for the present, as the energies of the staff will be fully occupied in making and confirming the very lengthy computations incidental to the publication of the series of papers above mentioned.

The mineral and vitamin requirements of growing swine (calcium, phosphorus and vitamin D).—An investigation into the effects of various biological factors on the growth rate of swine has shown that sex, condition, previous growth rate and age play no part in influencing the rate of liveweight increase. It was found that of the 800 life histories studied, hogs reached 70 lb. in 107 days, while gilts required 109 days, the small difference not being significant. Hogs attained a liveweight of 182 lb. and gilts 181 lbs., 11 weeks after reaching 70 lb. This part of the growth curve in swine was the same no matter whether the animals were only 80 days old or over 160 days old when they reached 70 lb.

Mr. Dunlop has evolved a new method of conducting animal experiments, and this has been employed in investigations here during the past two years. Complete details of this method have been published and the method is being adopted at certain other centres (35).

The vitamin D content of various cereals and protein foods used for feeding animals is being determined by biological tests on rats.

A further series of experiments undertaken to determine the Ca, P and vitamin D requirement of swine, has shown conclusively that even when kept indoors in complete confinement with no direct sunlight, cod liver oil and other vitamin D concentrates are not required from birth till bacon weight by swine fed the cereal and vegetable protein rations recommended by other advisory centres, provided common salt, limestone and ferric oxide are added in the correct proportions. If limestone is added in amounts over 2 per cent. the net energy value of the ration is decreased and growth of the animals is markedly retarded. Under such conditions of malnutrition, vitamin D supplements do exert an ameliorative effect.

A few analyses of samples have yet to be undertaken in a study of the effect of growth-rate, sex and genetical constitution on the quality of bacon.

Both a cereal—soya bean—mineral ration, and to a less extent a barley meal—middlings—fish meal ration, have been shown to be deficient in vitamin A for growth and normal health in bacon

pigs. Animals fed these rations from birth develop vitamin A deficiency. The animals assume increasingly lower planes of nutrition and gradually develop a staggering and incoordinated gait till finally they are unable to stand erect for any length of time. Growth ceases and the animals completely lose control of their hind limbs, which are drawn along the ground behind them when they move forward. Finally the animal is prostrate and develops spasms and twitchings of the whole body. It is unable to move and the fore part of the body has to be propped up when food is given. The blood picture, apart from serum cholesteral, is normal. The condition is distinct from rickets and bone diseases. Curative treatment with cod liver oil, carotene, vitamin A and large quantities of orange juice is successful. Preventive treatment consists of feeding the animals either four weeks before weaning, four weeks after weaning or both before and after weaning with a vitamin A supplement. Up till now raw liver has been used in the experiments. A vitamin A concentrate (cod liver oil) and foods rich in carotene, such as yellow maize and kale, are now being used to determine which is most suitable for preventing the disease by feeding to the young animals.

It has been shown, by analysis of the livers of 30 experimental animals for vitamin A, that provided the animal receives sufficient vitamin A during the suckling period of its life, it can store sufficient to meet its requirements (when the above rations are fed) till it reaches bacon weight.

Staggers in swine, as distinct from stiffness, is due to vitamin A deficiency.

Poultry nutrition.

Poultry calorimeter.—The construction of the calorimeter has been completed but heat tests carried out on the instrument showed abnormal variations which have required several months work to elucidate. The trouble has been satisfactorily elucidated, having been traced to the operation of two independent lags. Taking these into account, the performance of the instruments can now be satisfactorily prognosticated with precision for hours ahead from a knowledge of previous conditions.

Since the solution of this problem another has appeared, in the fact that the room thermostat although functioning excellently itself, has not been able to abolish temperature gradients in the room air, although this was stirred vigorously by means of fans. This difficulty, with others of a minor character, is now well on the way of being overcome, and it is hoped to complete the instrument so far as direct calorimetry determinations are concerned within the next year.

Digestibility determinations.—The work of previous years has enabled the construction of a suitable table of digestibilities of the commoner foods in use by poultry to be made, and in view of the

fact that other laboratories are now actively engaged on such determinations, no further work on this subject is contemplated in the near future.

Field investigations.—The data from the Bedfordshire egg laying trials for the years 1929-30, 1930-31 have been analysed by the method of least squares, and evidence has been obtained :

That this method of attack on the problem is suitable for application to field conditions, but in order to obtain results of extreme reliability it is essential to obtain the individual food consumption as well as the individual egg production and body weight. This can only be obtained by the use of specially constructed single bird pens.

The data from the Bedfordshire trials has given evidence that there is a breed variation in egg production food requirements, and that the food protein requirements for egg production is lower than the present accepted figures. The provision of the necessary accommodation will enable work on these points to be undertaken, and also the solution of the problem of the extent to which grass enters as a factor in egg production.

The physiology of fat metabolism in the fowl.—During the period under review, the effect of including small amounts of fat of different kinds in a standard cereal and soya bean ration low in fat has been investigated. The oils used in different groups were palm oil, soy bean oil, cottonseed oil and hemp oil, these oils being included to the extent of 5 per cent. in each case. The birds were reared in a battery brooder and subsequently in confinement. Owing to the impossibility of obtaining sufficient supplies of hemp oil, the hemp group were killed during the period of experiment.

During growth it was observed that the fat-free group grew better and were as a whole more satisfactory than the fat groups, and in addition feathering was distinctly better. During the latter stages of growth, these differences became much less marked.

During 1933-34 these birds will be used for hatchability tests to ascertain whether change in the composition of the egg fat affects the hatchability of the egg, and the composition of the body fat of the different groups will also be ascertained, in order to obtain further information on the effect of dietary regimes on the character of the body fat produced.

Fat from birds fed on a ration containing cereals and 10 per cent. fish meal was supplied to Prof. Hilditch of Liverpool University in October, 1932, in order that he might ascertain the composition of bird fat by the method of fractional distillation.

It was found that the fat supplied contained palmitoleic acid, a fatty acid hitherto associated only with oils of marine origin. In order that Prof. Hilditch might elucidate the point as to whether this acid arose from transference to the body fat from the fish meal, or whether it is actually synthesised by the bird itself, a

further supply of fat has been sent to him this year from birds raised on a special fishmeal-free diet, and on a diet from which cod liver oil has also been rigidly excluded.

On the biochemical side, results have been obtained which indicate that the hexabromide method of estimating linolenic acid in fatty acid mixtures often gives inaccurate results, and investigation of the thiocyanogen method of Kaufmann has been undertaken. It has been found that, with slight modifications, the Kaufmann method forms a rapid and accurate means of estimating this fatty acid in egg oil and other animal and vegetable fats.

Poultry genetics.

Mr. M. S. Pease is continuing his experiments on the commercialisation of the sex-linked Cambar breed of poultry. In the year under review 236 improved Cambars were trapnested; six birds gave over 200 eggs in their pullet years. This is a considerable improvement over the previous year, when only two birds reached the 180 mark. During the hatching season of 1933, Cambars were raised, as previously, by crossing Cambar cocks with Belgian utility Campines and by extracting from the Barred Rock-Cambar cross. There are now 350 Cambar pullets being trapnested.

Reproduction and growth.

Dr. Hammond and his colleagues have been continuing their work on the physiology of reproduction. Among other investigations the changes occurring during the oestrous cycle in the mare have been studied further. Ovulation has been found to occur about one day before the end of the heat; this has been determined by post-mortem findings and has also been demonstrated experimentally by rupturing the follicle per rectum. This technique has also been used as a means of studying the growth of the follicle and diagnosing the condition of the ovaries. These results, taken in conjunction with previous work on the fertility of matings made at different times during the heat period, give an explanation of the low fertility of matings made at the beginning and end of the heat period and the high fertility of matings made three to four days before the end of the heat. The work on the processes of reproduction in the mare has now been completed. It has been found possible to wash out the young embryo from the uterus without injury to the mother: this will cheapen the cost of artificial insemination experiments with mares.

The duration of the normal breeding season in grassland sheep (Suffolk × Border-Leicester-Cheviot) has been determined (from early September to late February) and the lambs born at different times of year—varying from January to late July—have been weighed to find out what differences, if any, occur in the rate of growth at different seasons. The breeding season occurs during

the long-nights period of the year and an attempt is to be made next year to induce breeding during the spring and summer months by the application of darkness.

A study of the effects of the seasonal and geographical changes in length of day on egg production in the fowl shows a close relation between the hours of light and egg production. It is suggested that light stimulates the anterior pituitary to increased secretion which in turn stimulates the reproductive organs. Many points raised by this statistical investigation require testing experimentally, and it is hoped that facilities for this may be available next year.

Dr. Marshall, in collaboration with Dr. F. P. Bowden, has been investigating the effects of different wave-lengths of light on the recurrence of oestrus in the ferret. The results at present indicate that all luminous rays are equally effective in causing heat outside the normal season, but that non-luminous (infra-red) rays are without result. A blind ferret (with cataract), although perfectly healthy in other respects, did not come on heat.

Dr. G. K. Smelser (U.S. National Research Council Fellowship) has found that when one testis is removed there is a compensating functional hypertrophy of the remaining testis, so that the number of sperm produced remain constant. He has obtained growth of the mammary glands in males by transplantation of ovaries into them.

Dr. Hammond's stock of inbred rabbits has been maintained to elucidate fundamental principles in reproduction and growth. It has been found that the dam has a controlling influence over the size of the young produced at birth, and possibly also on the conformation at a later age. This principle is now being tested out in its application to farm animals.

Previous research has demonstrated that the spermatozoa of the rabbit can be kept outside the body and the fertilizing capacity preserved for seven days. During the past year an attempt has been made by Dr. Walton to apply these results to the horse. A small stud of Shetland ponies (5 mares and 1 stallion) has been maintained for this purpose. Apparatus recently developed in Russia for the collection of semen has been used successfully, not only for the Shetland stallion, but also for a number of Shire and Percheron stallions in the neighbourhood. The apparatus may prove very useful in practice where a test of the stallions fecundity is required. The semen obtained has been subjected to various treatments in order to study the survival of the spermatozoa. Unlike that of the rabbit, the spermatozoon of the horse is very short-lived, but by employing various artificial media and by controlling gaseous exchange, survival of motility has been increased from about 12 to 24 hours. It is hoped that this survival time will be still further improved upon. In the meantime the technique of artificial insemination has been studied and some improvements on the standard methods

have been introduced. These experiments on artificial insemination have been combined with an experiment on the effect of the size of the parents on the size of the young. Semen from a Shire stallion was collected by means of the Russian apparatus and used to inseminate the Shetland ponies. One successful impregnation has been obtained. Similarly semen from the Shetland stallion has been used to impregnate a Shire mare, which is also apparently in foal. A comparison of the offspring from these reciprocal crosses should demonstrate the effect of the size of the parents upon the offspring—a problem of some considerable importance to the breeder.

Experiments on the effects of artificial lighting and castration on plumage changes in ducks have been continued and an experiment on the effects of light and darkness on ovulation in the rabbit has been carried out.

A series of observations on the consistency of the cervical mucus of the mare during the sex cycle and pregnancy has been begun with a view to determining the earliest time at which a diagnosis of pregnancy can be made by this means.

Dr. Hammond's measurements of fat, muscle and bone in the carcases of cattle, sheep and pigs have been continued at the carcase classes at shows. On the basis of these, assistance has been given to shows, breed societies, etc., to enable them to fix standards and give marks for judging and grading bacon carcases. Similar standards for pork pigs have been drawn up.

A scheme for " pig recording " has been prepared. The object of the scheme is to provide a measure of efficiency as regards fertility, milk production, rate of growth, and bacon qualities of pigs, so that the farmer can compare his results with those of others and measure the improvement caused by the use of new methods of breeding, feeding and management. It is hoped that it will show the way to lower the costs of production and improve the quality of the bacon pig.

Mr. R. Hirzel (University of Stellenbosch, Union of South Africa), has been working on fat, muscle, and bone measurements of mutton carcases to determine the change in the proportions with increase in the weight of the carcase within a breed : the results will give an accurate description of the carcases of different breeds and crosses of sheep and will indicate at which weight, or weights, the carcases of each breed show the proportions the consumer requires. By comparing the proportions of carcases of similar weights at 9 and at 21 months old he has been able to show the effect of a store period on the proportions of the different tissues in the carcase.

In conjunction with Mr. G. N. Murray (Department of Agriculture, Union of South Africa), curves have been drawn showing the prices paid at auction sales for beef, mutton and pork carcases

of different weights and of different qualities (as shown by breed differences). The object of this work is to give a scientific basis for the grading of meat carcases and to form an economic background for the studies of the proportions of fat, muscle and bone on these carcases.

A statistical investigation of butter fat production, which it is hoped will form a basis for studying fat metabolism in the animal has been commenced.

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30. ROWETT RESEARCH INSTITUTE, ABERDEEN.

In the laboratories of the Rowett Institute, research is carried out on the physiology of nutrition, and on the Duthie Farm attached to the Institute, practical experimental work is done with groups of farm animals.

Rowett Institute.

Nutrition and Disease.—The evidence which has accumulated in the last few years shows that the state of nutrition as determined by feeding is an important factor in the incidence of many diseases which are common in farm stock. During the past year investigations on this subject on which the Institute has been engaged for a number of years, have been continued and extended. There is, however, little new in the past year of interest in connection with the practical application of this work. The acquiring of the knowledge of the influence of various nutritional factors on the living processes of the body upon which health depends, is difficult and tedious. It involves the accumulation of masses of data of a highly technical nature. In many cases the data have to be accumulated over a series of years. These technical results which are of interest only to research workers engaged in similar studies, are published from time to time in the appropriate scientific journals, but a statement with regard to the practical bearing of the information being obtained has often to be deferred for two

or three years, even in cases where the investigations are successful in yielding results of practical value. In this report, therefore, one can deal only with the general nature of the investigations and indicate the lines along which progress is being made.

In previous work it has been found that when animals are maintained for long periods on rations deficient in certain minerals and/or vitamins, the composition of the blood, especially with regard to the concentration of calcium and inorganic phosphorus, becomes abnormal and that these changes in the blood are connected with symptoms of disease. In last year's report it was intimated that some observations had suggested that before changes in the calcium and phosphorus level can be noted, there is a change in the level of the enzyme phosphatase, which thus becomes of importance as a very early indication of malnutrition. This observation has been confirmed during the past year in sheep kept under various dietary conditions. Observations have also been made upon cows at the time of calving when the composition of the blood is liable to be abnormal, an excessive abnormality being connected with milk fever. It has been found that there is a lowering of plasma phosphatase just before parturition with a high concentration in the blood of the umbilical cord and in that of the newly born calf.

It has been shown in work on sheep, referred to in previous reports, that these changes in the blood which can be measured by chemical analyses, are accompanied by changes in the immunological reactions by which the body protects itself against infection. Tests with the toxin of lamb dysentery were repeated last year. They confirmed previous observations that the reaction to the toxin is more marked in the case of animals whose blood is abnormal, due to deficiencies in the ration than in those on a better balanced diet and consequently in a better state of nutrition as indicated by the blood picture. This work has been continued during the year, tests being made on different groups of sheep each on different diets.

Detailed examination of the intestinal tract of rats fed on diets deficient in vitamin A have shown that minute lesions in the intestine occur at an earlier date than had been supposed, and that the appearance of these lesions precedes the ordinary gross clinical symptoms of malnutrition.

The purpose of these observations on the changes in the blood and in the functions and appearance of the intestine is to ascertain the nature of the first deviations from the normal in animals on faulty diets, and the factors in the diet which are responsible for these changes. It is hoped that researches of this kind will yield information which will enable the very slight early symptoms of disease to be prevented.

In last year's report it was stated that chemical and serological examinations of the blood of a group of milk cows fed on an ordinary ration were being carried out throughout the complete annual cycle

of pregnancy and lactation. During the past year the ration of half of these cows has been modified to make it as perfect as possible from the point of view of health. The ration of the other half has been made worse, though it is still such a ration as might be commonly fed. Examination of the blood is being continued. No change was noted for the first three or four months. Then there occurred a gradual decrease in the milk yield of the group on the poorer ration. There is now beginning to appear evidence of changes in the composition of the blood. This work will need to be carried on for a considerable period before definite results are obtained.

In a group of ewes which were under experiment to determine the calcium and phosphorus balance through the annual cycle of pregnancy and lactation, it was found that some of the ewes on the poor ration developed a condition resembling, if not identical with pregnancy toxaemia, a condition which occurs both in animals and in women. This condition was associated with certain abnormalities in composition of the blood. The condition is being investigated in the hope that something may be learned of the cause of eclampsia and related conditions.

Intestinal absorption.—There is reason to believe that disturbances of the functions of the digestive system and a pathological condition of the mucous membrane of the stomach and intestine are amongst the earliest symptoms of disease due to faulty nutrition. For this reason researches dealing with the function of the intestine are being continued.

It has been found during the past year that removal of the nerve control of the alimentary canal increases the rate of absorption of sugars. It is possible that this observation may account for the disturbances in nutrition when animals are excited or disturbed during feeding, because if the removal of nerve control accelerates absorption, the opposite, viz., stimulation, may retard this process.

Other work during the year suggests that the rate of absorption of food may be influenced by the amount of phosphates in the alimentary canal.

Minerals required in traces.—The feeding experiments on rations with fluorine, referred to in last year's report, have been completed. The results have confirmed in a general way what was believed to be the evil effects of an excess of fluorine.

Physiology of the fowl.—The effect of radiostol on the calcium and phosphorus balance of cocks has been studied. The radiostol increases the level of the phosphatase in the blood. In hens it has been found that the phosphatase level is higher in laying hens than in those not laying when the diet is deficient in calcium. The interest in these researches lies in the possible relationship of this enzyme to egg shell formation.

Studies of carbohydrate metabolism in the fowl suggest that insulin may be secreted elsewhere than in the pancreas. The

carbohydrate metabolism of birds appears to be rather different from that of mammals. It is probable that this study may throw some light upon this aspect of physiology in both birds and mammals.

Other work.—Biological tests to determine the amounts of vitamin A and vitamin D present in a number of kinds of fish oils have been completed. The results will be of use in indicating the relative nutritive values of these oils.

In last year's report it was stated that the results of certain experiments with sheep and poultry had suggested that crude cod liver oil might contain some factor other than vitamin A and D, affecting rate of growth. These experiments have been repeated under more exact conditions and the first observations have not been confirmed. It is probable that the crude cod liver oil used in the earlier experiments may have contained traces of liver or that the vitamin A and vitamin D fed in pure form were not completely assimilated.

In studying the behaviour of sugar and lactic acid in the blood of sheep, it has been found that if the animals are driven and hustled before bleeding, there are increases in the amounts of these present in the blood. The rise also occurs when sheep are excited by a barking dog. It is probable that the rise is due to emotion causing an outpour of adrenaline into the blood. It is suggested that the high concentration of lactic acid in the muscle may be an explanation of the fact that meat tends to be of poorer quality when the animals are killed immediately after being hustled and excited, than if the animals are previously rested.

The work in conjunction with the Hannah Institute to ascertain whether dried separated milk can be fortified with vitamins has so far yielded negative results. It has been found that the method of drying destroys the vitamins added before drying.

Human dietetics.—The work on human dietetics in conjunction with the Public Health Department and the School of Medicine in Aberdeen, has been continued. In tests with school children in Peterhead it has been found that the administration of vitamin A is not followed by any marked improvement in health. The beneficial effects are almost negligible compared with the effects of extra milk either whole or separated.

An examination conducted by Professor Davidson has shown that nearly 50 per cent. of women in the poorer districts in the city of Aberdeen suffer to some extent from anæmia, and that this anæmia can be cured by the administration of iron salts. In experiments with rats at the Institute, it has been found that anæmia develops in breeding rats if fed on a diet similar to that of the women suffering from anæmia.

It is interesting to note here that in connection with the above work dietary surveys were made in 1932, in the same districts as surveys were made in 1927. In the intervening five years, the

diet has become worse, especially in Peterhead, where there is a considerable amount of poverty. The average milk consumption in Peterhead has fallen from ·56 to ·36 pints per head per day.

This joint work with those engaged on purely medical research in nutrition, is of advantage to the work at the Institute. The various diseases found in the human population associated with faulty diet, appear to be identical with those produced in animals under experimental conditions. Information gained upon the cause of these conditions in humans throws light upon the same condition in animals, and vice versa.

Duthie Experimental Stock Farm.

Sheep.—In co-operation with the North of Scotland College of Agriculture, an investigation has been undertaken to ascertain the extent to which parasitic worms are present in sheep in different districts, and the effects of the infestation on the health of the sheep. Out of 545 replies to questionnaires issued to sheep farmers, 296 report losses believed to be due to worm infestation. Thirty-five farms have been visited and the sheep examined. Some of the sheep have been killed and the intestinal tract brought back to the laboratory. A differential count is now being made of the parasites found. It is believed that the results of this work will throw much needed light upon the extent to which parasitic infection by worms is a factor of economic importance.

Poultry.—The experiments outlined by the joint poultry Research Committee of Scotland and Northern Ireland have been continued. It has been found that with high levels of soya bean meal, a form of leg-weakness develops in chicks. So far, it has been impossible to determine whether this condition is associated with the peculiar kind of soya meal used, or is due to some mineral, vitamin or amino acid deficiency.

In the experiments begun three years ago to determine the period of the year at which it is most profitable to hatch at the present price of eggs, the results so far indicate that the beginning of April is the optimum date, at least for Leghorns, on which these experiments have been conducted.

In collaboration with the Chemist to the Highland and Agricultural Society, tests have been done to determine the effects of feeding excessive amounts of salt. Death occurs when the amount given rises to about half an ounce per head per day. Severe diarrhœa is the most marked symptom of excess. The optimum amount of salt in an average cereal ration with soya bean as the protein supplement appears to be about one half per cent. of the mash.

Cattle.—Experiments to determine the most economical rearing of calves have been continued. It is found that the rearing of up to eleven calves per cow by suckling is practicable under good management.

Pigs.—Joint experiments with the College of Agriculture have been done to demonstrate the comparative value of commonly used rations. Special attention is being given to rations containing farm by-products and home grown feeding-stuffs, e.g., whey, potatoes and oats.

Other experiments are being carried out to ascertain the amount of green food in the form of cabbage which the growing pig can efficiently utilise. Green food is an excellent source of both minerals and vitamins liable to be deficient in a cereal ration. It has, therefore, a special health value.

Pastures, fodder conservation, and feeding trials with dairy cows.—Our increasing knowledge of the botanical characteristics of the various herbage plants and of manuring has brought pastures in recent years to a high level of stock-carrying capacity in summer. The balance between summer grazing and winter crops in the ordinary rotation has tended to become upset and the problem is now one of how best to conserve most effectively the surplus grass at the peak of production in summer. It is also believed that, since winter feeding has tended to become unprofitable, it may be economical to encourage the production of late and early growing pastures. By this means stock might be left outside longer, winter feeding becomes less expensive and stock thrive better when they go on to summer pasture.

An experiment has been planned to test in which of the following states surplus grass can be most efficiently preserved.—(i) Hay; (ii) silage, cold fermentation process; (iii) silage, cold fermentation process plus molasses; (iv) silage, with the addition of acid and molasses (D.E.F.H. solution); and (v) silage with the addition of A.I.V. acid.

A record is being kept of the produce per acre and, by analysis and weighing, of the losses incurred in preserving by the different methods. In addition, feeding trials are being carried out with the different materials to test their palatability.

Another method of conservation is by artificial drying. Dried grass was not available, but a feeding trial was carried out on dairy cows with dried lucerne. The swing-over method was used. When 10 lbs. of dried lucerne replaced 15 lbs. of swedes, 4 lbs. (approx.) oat straw, and 4 lbs. concentrates in the maintenance ration, there was a distinct check in the normal fall in milk yield. Colour tests showed that the fat was distinctly more yellow on the dried lucerne ration. Further experiments with dried grass are being carried out to confirm these findings with lucerne.

A number of silos to hold 15 to 20 tons of silage were constructed to see whether and by what treatment a green fodder crop consisting of a mixture of oats and legumes could be most practically conserved for use for outwintered stock. Some of the silos were filled by a silo-cutter in the ordinary way; in others the material was ensiled in the long state. Acid was applied in both cases with

an untreated control in each case. The respective losses are being determined by analysis and tests of the palatability of the material and its keeping qualities are also being made.

Plots have been sown out to test the production of the individual grasses of a mixture, as compared with the same grasses in mixture. Suitable manuring for the individual grasses and for the mixture is being applied, and the production will be measured by stock-carrying capacity and by taking samples at random from plots for analysis.

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31. (CHEMICAL AND) ANIMAL NUTRITION DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Poultry Nutrition.

Chicken rearing.—Previous work had demonstrated that liquid milk prevented the appearance of a form of legweakness, which was not rickets or slipped tendons and was characterised by the turning in of the toes. As the condition advanced the birds walked on their hocks which generally became enlarged. It was found that the addition of dried skim milk powder to a ration of cereals and soya bean meal and salt gave improved growth and prevented the occurrence of this form of legweakness. A supplement of dried yeast had similar effects. The protein levels of the rations were kept constant for all groups by adjustment of the content of soya bean meal. The incidence of the legweakness was not affected by supplements of sulphur, sodium sulphate or magnesium sulphate. In a comparison of a cereal mash supplemented with soya bean meal at levels of 18, 34, and 50 per cent. slightly higher growth rates were produced by the use of the higher amounts of the protein supplements but the results were complicated by severe legweakness in all three groups.

Laying experiments.—As good results were obtained from the use of limestone grit as from the use of oystershell grit. No response was apparent from the addition to the mash of 5 per cent. ground limestone in addition to offering oystershell grit *ad lib*. An orthodox laying ration was compared with a mash of boiled potatoes, crushed oats and maize meal, with oats as scratch grain. The latter ration led to a rather low level of production when used alone, but when supplemented with as much separated milk as the birds would drink it gave results comparable with the orthodox ration. When common salt alone or common salt and steamed bone flour were used as supplements in place of separated milk the level of production was intermediate between that of the unsupplemented ration and that of the orthodox ration. The mash consumption of all the groups receiving potatoes was more than double that of the control group.

A comparison was made of the value of soya bean meal, meat and bone meal, fish meal and a mixture of soya bean meal and meat and bone meal as supplements to a laying mash of cereals. No significant differences were found.

It was found that the level of egg production was unaffected when a laying mash of cereals plus ·5 per cent. common salt was supplemented with 7 per cent., 14 per cent. and 20 per cent. soya bean meal (2). This held not only for the number of eggs but also for the market value and size of eggs and the weight and health of the birds.

In a further experiment it was found that as a supplement to a ration of cereals and salt the use of soya bean meal at the rate of 20 per cent. of the mash did not affect the level of egg production etc. whether the hens had grass on their runs or not.

Mineral balance studies.—The experiments mentioned in last year's report concerning the mineral metabolism of laying pullets formed the subject of a further paper (3).

Silage.

Co-operative work is in progress on the comparative values of different methods of making grass silage. Four methods are being used, namely, ordinary grass silage, molasses silage, and two methods involving the use of acids. Records of nutrient losses are being kept. Digestibility trials with sheep are being carried out on the grass from which the silage is made, hay made from similar grass and also on the four different types of silage.

Composition of Milk.

A further analysis of the data collected at the Agricultural Research Institute for Northern Ireland (4) reveals that, even with a well managed herd, milked at reasonable intervals, over 20 per cent. of the samples from single morning milkings were below the presumptive legal limit; and that nearly 10 per cent. of the morning samples and 13 per cent. of the evening samples were below the presumptive legal limit for solids-not-fat. The low butterfat tests occurred mainly in late spring and early summer, while the low solids-not-fat tests occurred in late summer and early autumn. The causes of these results are discussed, and suggestions for the amendation of the existing Sale of Milk Regulations are put forward.

A report based on the milk recording data collected in Northern Ireland (5) shows that very substantial increases in milk and butterfat yields have been obtained and that, if the fullest benefit is to be derived from milk recording, the keeping of records must be continuous. The data indicate that an average yield for an Association of 700 gallons can be maintained and improved. Tables are given which show that low yielding cows are being eliminated from herds, that the remaining cows are being better fed and managed, and that more interest is being taken in the production of winter milk. It is also shown that a greater percentage of heifers are being retained in herds. A most important fact made evident by the tables is that the average yield of the 1930 heifers exceeded that of the 1924 heifers by over 100 gallons. Milk recording data are also being used to study the transmitting ability of dairy bulls.

An investigation of the value of the freezing point test has been carried out. The conclusion reached is that the freezing point test may be used with confidence to establish the genuine nature of a sample of fresh milk, or of a sample in which only a moderate

degree of acidity has developed. If acidity has developed in a sample, the original value of the freezing point can be approximately obtained by means of a correction. The initial or natural acidity had little or no effect on the freezing point. A distinct seasonal variation in the freezing point of herd milk was found, but the influence of the stage of lactation was not definitely traced.

An examination of amyl alcohols for milk testing (6) showed that there may be wide variations in the physical characteristics of the alcohols alleged to be suitable for milk testing. The general conclusion arrived at was that amyl alcohol for milk testing should be guaranteed to give, when used in the Gerber method, a butterfat test with an error of not more that ±0·05 per cent. of butterfat, as compared with the result obtained by the Röse Gottlieb method.

Titles of papers issued during the year.

1. Prentice, J. H.: The rôle of salt in poultry nutrition. *J. Min. Agric. N. Ireland*, **4**, 72, 1933.
2. ————: The amount of protein rich supplements required in practical laying rations. *Ibid.*, **4**, 116, 1933.
3. Common, R. H.: Observations on the mineral metabolism of pullets. *J. Agric. Sci.*, **23**, 4, 555, 1933.
4. Houston, J.: The legal standards for butterfat and solids-not-fat. *J. Min. Agric. N. Ireland*, **4**, 47, 1933.
5. ————: The progress of milk recording in Northern Ireland. *Ibid.*, **4**, 37, 1933.
6. ————: The use of amyl alcohol for milk testing. *Analyst*, **58**, 151, 1933.

32. PIG HUSBANDRY EXPERIMENTAL STATIONS.

(A) Harper Adams Agricultural College.

Four experiments were completed during the year, the nature and results of which are briefly summarised below :—

(i) Dried grass ground to meal proved barely equal to sharps. Owing to bulkiness and laxative tendency the proportion that could be conveniently included in rations was relatively small. The material used was not entirely satisfactory, the protein-content being much lower, and the fibre-content higher than is commonly expected in young grass.

(ii) No economic advantage was found from warming the food supplied to pigs during the winter. In the earlier stages the young pigs ate the warm slop more readily and showed a rather better " bloom ", but at no stage was this accompanied by a higher rate of growth.

(iii) Two groups of pigs given daytime pasturage for four weeks and eight weeks respectively after weaning gave better liveweight gains during these periods than a third group that was housed immediately after weaning. The initial

advantage thus secured was maintained, but not appreciably extended, during the subsequent feeding period. No differences between the groups in carcase quality could be detected.

Owing to the abnormal character of the Summer of 1933 this experiment is not regarded as decisive of the point at issue.

(iv) A pure meat meal, containing 84 per cent. of protein, gave a rather better rate of growth than a commercial meat meal containing 54 per cent. of protein, when the two were used in proportions supplying the same amount of protein. Some doubt is expressed, however, whether the difference was wholly due to any intrinsic superiority of the high-grade meal.

Titles of papers issued during the year.

1. Crowther, C., and Wright, T. S.: Harper Adams pig feeding experiments, 1932-33. *Pig Breed. Ann.*, 13, 146-163, 1933-34.
2. Wright, T. S.: Ground oats for pigs. *Scot. J. Agric.*, **16**, 1, 72-78, 1933.
3. ————: Potatoes and the pig. *J. Min. Agric.*, **40**, 7, Oct., 1933.

(B) South Eastern Agricultural College, Wye.

The feeding and management of sucking pigs.—During the year the rearing of young pigs which are confined to styes has been studied. It has been consistently observed that young pigs which are confined to styes do not start to eat supplementary food until they are six or seven weeks old and that pigs which do not start to eat supplementary food when between four and five weeks old deteriorate in condition—the deterioration being progressive until they do start to eat. During the year under discussion it was found that young pigs which refused a normal cereal ration would eat liver or lean meat from the age of three weeks old. The use of ¼ oz. of liver or lean meat per pig per day was found to arrest the deterioration in condition referred to above.

The value of a run out on grass for growing pigs.—The results obtained in this series of trials indicate that store pigs which have free range on grass are more healthy, have a better appetite and eating more meal make more rapid growth than those confined to styes; the feeding value of the grass eaten is small; and that in order to secure the most economical utilisation of meal with pigs which have free range on grass it is necessary to use a balanced ration and feed to appetite.

The use of 10 per cent. of fishmeal containing 9 per cent. oil right up to the time of slaughter was found to impart no undesirable flavour to the carcase when used as fresh pork.

Title of paper issued during the year.

Fishwick, V. C.: Progress report. *J.S.E. Agric. Coll.*, No. 33, Jan., 1934.

33. NATIONAL POULTRY INSTITUTE.

(A) National Institute of Poultry Husbandry, Harper Adams Agricultural College.

Production of Table Chickens.

Studies were made on the rate of growth and fattening of twelve groups of La Bresse × Light Sussex chickens.

Three groups reared in batteries to eight weeks made as good gains in weight as three groups normally reared. Rearing in batteries to eight weeks did not affect the subsequent rate of growth after eight weeks. Two groups reared in batteries to fourteen weeks made similar gain in weight to two groups normally reared (i.e. floor brooded and range reared).

Birds reared in batteries made as good gains in the fattening shed as normally reared chickens. The battery reared chickens had a good finish and fetched as high prices on the London Market as normal reared chickens.

Chickens ten days trough fed plus ten days crammed, made better gains in weights than chickens trough fed twenty days.

Chickens trough fed twelve to fourteen days were as heavy as chickens trough fed twenty days.

Four groups of chickens trough fed on the run made as good weights as four groups trough fed in the fattening shed. Further data is being collected on this important subject for the different seasons.

Waterfowl and Turkey Production.

Table duck production.—Cereals plus soya bean meal, salt and calcium, made very suitable rations for the production of table ducklings. Cereals plus 10 per cent. soya bean meal gave as good results in the production of table ducklings as cereals plus 20 per cent. soya bean meal.

Duck egg production.—Two pens of ducks fed a ration of cereals plus soya bean meal and minerals, gave as good egg production as two similar pens fed the same basal cereals plus fish meal. The fish meal pens gave slightly larger eggs than the soya bean meal pens.

Goose production.—Further studies have been made on the rate of growth, and food consumption of geese. It was found that grazing geese from six weeks onward gave as good a rate of growth on grazing plus supplementary feeds of mash and grain. The group that was grazed only from six weeks to the fattening stage gave a handsome profit over food costs, whereas the control left only a small margin over food costs.

Turkeys.—Previous experiments have shown that turkeys reared intensively grow normally and give a handsome profit, and that intensive rearing was an effective method of controlling blackhead

disease in turkeys. During 1933 the rate of growth of intensive-reared turkeys was compared with that of normal-reared and at the close of the experiment the normal-reared turkeys were on an average 1 lb. heavier than the intensive-reared birds.

Statistical Department.

National Institute of Poultry Husbandry.—The results of incubation have been analysed. Chicken rearing experiments have yielded data on the individual weights of chickens at fortnightly periods.

In all egg laying experiments, complete summaries have been made for each monthly period of the test, and at the end of each experiment the complete records of egg production and weights were summarised and the significance of differences was tested.

The data resulting from the rearing and fattening of twelve different hatches of chicks (2,100 chicks) have been summarised.

Experiments were conducted with approximately 600 ducks, weighed individually at different periods and the results treated statistically.

Harper Adams Laying Trials.—Records of egg production and weights have been summarised on similar lines to that of previous years.

Northern Breeding Station, Reaseheath.—The whole of the records of experiments from 1924-1931 have been summarised and a report on the results made to the Sub-Committee. Tables of results have been prepared for a paper read by the Station Superintendent at the Midland Agricultural College.

The Statistician has been requested to prepare a draft bulletin dealing with these experiments for the assistance of the Sub-Committee.

Investigations have been made to ascertain the degree of correlation between the average egg weights for a dam and the average egg weights for her daughter.

Southern Table Poultry Experimental Station, Wye.—Complete summaries have been made of the experiments carried out in 1930 and 1931. Some considerable time has been spent in detailed examination and criticisms of the drafts of the bulletin which the Sub-Committee is submitting to the Ministry of Agriculture. This bulletin deals with the experiments carried out from 1929-32.

(B) Reaseheath : Cheshire School of Agriculture (Northern Breeding Station).

The main line of work at this Station is a series of experiments that has been initiated to test the respective merits of cross breeding (i.e. first cross) v. pure breeding. Cross breeding, which has tended to fall into disrepute through the amount of indiscriminate crossing which was all too common a generation ago, is

now regaining some popularity, partly as a result of defects perpetuated in pure breeds and partly by reason of the simplification of management which sex linkage permits. By using the method of diallel crossing, it is hoped to obtain comparative data on a number of factors which are of practical importance to the poultry keeper, viz. fecundity, hatchability, rearability, rate of growth, time of reaching maturity, cost of rearing, egg quality etc.

An experiment has been commenced on a small scale in an endeavour to produce from one of the popular commercial breeds a strain of poultry capable of withstanding continuous in-breeding.

Preliminary experiments are also being carried out in the endeavour to determine whether infertility in White Wyandottes—whatever may be its cause or causes—is inherited or not.

A study of some interest on rearing results has recently been drawn from the data at the Station. A paper on the subject was read at the meeting of the National Poultry Council in April, 1934, and subsequently published.

Titles of papers issued during the year.

1. Parkhurst, R. T., and McMurray, M. R.: Factors in the development of deforming leg weakness in chickens. *J. Agric. Sci.*, **23**, 2, 1933.
2. Tallent, V. K.: Intensive turkey rearing, 1932. *Harper Adams Utility Poult. J.*, **18**, 4, 1933.
3. Dudley, F. J.: The degree of reliability of poultry feeding experiments. *Ibid.*, **18**, 6, 1933.
4. Tallent, V. K.: A comparison of fish meal with meat and bone meal for laying ducks. *Ibid.*, **18**, 8, 1933.

(C) Wye: South-Eastern Agricultural College (Southern Table Poultry Station).

The principal channels of investigation during 1932 were concerned with the possibility of reducing feeding costs during the fattening period without impairing the quality or weight standard of the table bird produced. For this purpose chickens in the main experiment were divided into three groups in the fattening shed and fed on the following rations:—

(i) Ration "S" 13 parts Sussex ground oats and 1 part dried skim milk.

(ii) Ration "M" 6½ parts white maize meal, 6½ parts Sussex ground oats and 1 part dried skim milk.

(iii) Ration "B" 6½ parts barley meal, 6½ parts Sussex ground oats and 1 part dried skim milk.

The approximate cost of these rations per cwt. was—"S" 10s. 1¼d., "M" 9s. 4¼d. and "B" 9s. 10d.

It is interesting to compare these prices with the cost of the standard fattening ration used for some years on the Station and on most fattening establishments (Sussex ground oats 13 parts and dried skim milk 2 parts), which was 11s. 10d. per cwt.

The general conclusions which may be drawn from these experiments are briefly :—

(*a*) That rations " S " and " B " gave generally better fattening results at generally less cost for food than ration " M," while the appearance of the finished birds in the groups fed on the first-mentioned rations were also superior, especially during the summer months. At the same time, there was very little difference in the market prices per lb. realised.

(*b*) The fattening results obtained with ration " S " were generally slightly better than those for ration " B," although the cost of the food consumed was slightly higher. At the prices for feeding stuffs ruling in 1932, however, there was relatively very little difference economically.

The 1933 experiments were designed to investigate the best possible way of conditioning table poultry, the returns that might be expected if birds were not conditioned at all, and what results could be obtained by trough feeding only as against a period of trough feeding and cramming.

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34. SMALL ANIMAL BREEDING RESEARCH STATION, CAMBRIDGE UNIVERSITY.

Work has proceeded with the investigation on fecundity in poultry. Some experiments on the inheritance of blue egg colour in fowls were brought to a close and the results published (1).

Experiments with sex-linkage in ducks have been pursued, and it is expected that a Dark Runner breed suitable for the purpose will be shortly established.

Various experiments concerning coat colour in rabbits are proceeding.

Title of paper issued during the year.

1. Punnett, R. C.: Genetic studies in poultry. IX. The blue egg. *J. Genet.*, **27**, 465-470, 1933.

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35. INSTITUTE OF ANIMAL GENETICS, EDINBURGH UNIVERSITY.

Poultry.

The data on secondary sexual characters, body weight, endocrine glands, etc., of the Brown Leghorn which have been collected during the past years are now being analysed and prepared for publication. It was shown that while many of the structural characters used as indicators of egg production are unreliable the condition of the hen's comb is closely allied with the productivity

of the bird. The comb remains large during the laying periods but regresses during the moult, i.e., non-laying period. In good producers the crest of a curve for comb size is long and smooth with a sharp dip at the moult followed by an equally sharp rise. In bad producers the crest is irregular and broken by many dips and the regression during the moult is prolonged (23).

The decrease in production with age is mirrored in the comb cycle curves for aged birds in which a yearly widening of the moult dip is characteristic. Attention is drawn to three types of comb cycle which indicate the possibility of increasing the productiveness of the fowl :—(i) A four year old bird had an almost similar comb cycle in each succeeding year, i.e., the length of the crest and the size of the moult dip were about the same while egg production for the four years was 210, 194, 193 and 187 respectively—the production in the fourth year being only 11 per cent. below that in the pullet year. The possibility of this type of production being hereditary is under test. (ii) Three hens have occurred in the stock in which the autumn moult is completely absent and egg production continues throughout what is usually the non-productive period, and a fourth bird is apparently also showing this phenomenon. The possibility that this character is genetic seems probable for all four birds are closely related and three possess a common ancestor in the fourth. Pens of their progeny are now being mated up and inbred in an endeavour to fix the character. (iii) Preliminary attempts to delay or delete the moult period by physiological methods have been made on a few birds. A normal female which had carried testis grafts from an early age showed three normal female comb cycles in which the onset of the moult dip occurred at the same time in each. Between 3rd August and 20th December the bird received 248 grafts of fresh fowl anterior pituitary gland and a marked effect was obtained on the comb which showed only a fraction of the normal dip and returned to its full size at the usual time. A true moult did not occur. Since the presence of testis grafts suppressed the activity of the ovary the behaviour of egg production could not be studied in this case.

Two non-laying adult hens were subjected to a series of injections of anterior pituitary substance; their combs developed and they began to nest but did not lay. Both were killed and on post-mortem it was found that while the ovary had been greatly stimulated and was producing large numbers of eggs, these were being shed—not into the oviduct—but into the abdominal cavity indicating that the ovary had been activated more rapidly than the oviduct and was shedding eggs at a time when the latter was not yet sufficiently developed to receive them.

Tests and assays of sex hormone extracts and synthetic hormones have been continued in conjunction with Professor Dodds of the Middlesex Hospital. During the present year these experiments have been chiefly directed to the isolation of synthetic substances which produce a reaction comparable with that of the female hormone (oestrin).

In connection with a scheme for the International standardisation of male hormone initiated by Professor Koch of Chicago a large series of injections of male hormone into capons was carried out. The results are being compared with those obtained from laboratories.

The behaviour of the capon (Brown Leghorn) in its response to oestrin (feather test) is being studied rather fully and the proportional effects of different doses, and dilutions, and possibility of seasonal or other environmental variations, etc., examined.

The question of whether the capon feather test for oestrin might be utilised in the diagnosis of pregnancy has been under consideration. It is known that in the mare large quantities of oestrin are excreted in the urine during the course of pregnancy and if the hormone was in sufficient concentration it was hoped by injecting suitable doses into capons to obtain a reaction in 48 hours in the feathers according to the method first used by Juhn and Gustavson. Twenty-four samples of urine have now been examined and while the actual facts with regard to the pregnancy or barrenness of the mares in question will not be available for several months, the results agree in every case with results obtained from tests in mice with urine from the same sample. In all positive cases the diagnosis was possible 48 hours after the first injection which is three days earlier than is possible with the mouse test.

Studies on the genetics of *Drosophila pseudo-obscura* have been continued. Some twenty-five new mutations have been recognised and their genes are being recorded. Several of these mutant characters are of considerable interest for the reason that they will provide material for the study of developmental physiology.

By the use of X-rays it was found possible to demonstrate the mechanism of chromosome elimination. It is concluded that the loss of the segment of the chromosome carrying the attachment constriction following upon fragmentation was primarily responsible for the deletion of the chromosome from the complex. Cytological study of the sterility of the hybrid male of *Drosophila pseudo-obscura* races A and B revealed that the penultimate cause of sterility is the absence of association of corresponding chromosomes during meiotic prophase and metaphase. Genetical studies on the interracial hybrids show that reduction of crossing-over in one portion of the chromosome is always associated with an increase of crossing-over in the remaining portions of the same chromosome. Comparative studies on the meiotic processes in related species of geographical races such as *Crepis* and the marsupials, locusts and grass-hoppers, have shown that these differ amongst themselves in respect of chiasma frequency, of diplotene and also in terminalisation.

The genetic and cytological examination of a gold cock out of a Light Sussex × Rhode Island Red mating has been completed. It was shown that this exceptional cock was a case of non-disjunction of the sex-chromosome, that he must have received both of his

X-chromosomes from his father. Though this phenomenon is well-known in certain other forms, this is the first case to be recorded in the fowl and provides one explanation for unexpected results of sex-linked matings. The study of the genetics of " slit-eye " in the White Leghorn and of a ragged plumage exhibited in the Rhode Island Red is being continued, as is also the study of the genetics of plumage colour in the Muscovy duck. The study of sterility of the hybrids between Muscovy and Aylesbury ducks has been completed, and it has been shown to be due to an incomplete meiosis, the cause of this being genetical and the direct result of hybridisation. This cross possesses another feature of interest in that owing to differences in the syrinxes of the two species their voices are quite distinct and dissimilar, whilst those of the hybrid are like that of the Muscovy parent.

A peculiar waved condition of the coat of the mouse was shown to be a monogenic autosomal recessive. It will prove to be a useful character for linkage studies in this species.

The experiment which has for its object the re-examination of the conclusions of Professor William McDougall relating to the inheritance of educability in the rat has been continued. It now seems quite clear that the Lamarckian interpretation suggested by Professor McDougall is unwarrantable, and the experiment is now proceeding to an examination of the inheritance of behaviour patterns (19).

Studies in the genetics of plumage colour in the turkey have been continued. Results of considerable interest have been obtained, but it is quite clear that the experiment demands far greater numbers of birds than can be maintained here under present conditions. In future this particular experiment must either be abandoned or else restricted to the study of but one or two characters at a time. However, results already obtained have enabled the Institute to explain to several breeders the reasons for their failures to maintain a stock with an unchanging characterisation.

Cattle.

The statistical investigation into the inheritance of milking capacity in cattle has been continued and the figures to which reference was made in the previous report are now in process of final analysis. The data for this study were furnished from three herds of the Dairy Shorthorn breed, each herd being treated as a separate entity. This meets the major criticism of our previous work in the Ayrshire breed, that the variation in the influence of the different ancestors might be due not to genetic causes but to the fact that there was a tendency for cows related through a common paternal grandsire to complete their records in different herds, whereas cows related through a common maternal grandsire tended to be confined in the same herds. Thus in the present Dairy Shorthorn study this possible variation has been eliminated. The results conclusively show that the paternal grandsire has an

appreciably lesser influence on the milk yield of his grand-daughters than has the maternal grandsire. The only interpretation which can be placed upon this fact is that one or more genetic factors transmitted in a sex-linked manner play an important part in the inheritance of milking capacity. A detailed examination of the herds and of sections of the herds would appear to indicate that autosomal inheritance is of importance. The tentative conclusion is being drawn that only one gene, affecting total milk yield, is transmitted in a sex-linked manner but that this gene is of major importance, having an effect equivalent to approximately 300 gallons.

The same Dairy Shorthorn data have provided interesting information on the performance of the progeny of various bulls. Here again the figures are of particular value since environmental factors are reduced to the minimum. From a preliminary analysis the striking fact emerges that whereas there are some bulls whose daughters show great variation in their yields of milk, there are other bulls mated to the same population of cows, the variation of the yields of whose daughters is comparatively small. This would appear to be a fundamental point in the practical selection of bulls of dairy breeds.

At the experimental farm at Shothead the work continues on the experiment designed to show whether sex-linked factors are of practical importance as regards the inheritance of milk yield. The first cross heifers between high and low yielders are now some 18 months of age and are being mated. It will thus be two years before it will be possible to make the first report upon their performance. The other records continue to be kept, dealing with the composition of the milk as regards butterfat and specific gravity, economy of food consumption (i.e., amount of food per gallon of milk), effect of meteorological factors, and the relation of conformation to production. The work on the latter point has been considerably hampered by a shortage of adequate scientific assistance.

An examination of the animals at Shothead as well as of other herds shows no physiological relation between the shape of the escutcheon and the yield of milk. The shape of the escutcheon however appears to be definitely genetic in its origin and the suggestion is made that where positive results have been obtained this is due to the chance association of factors for high milk production with factors for certain types of escutcheon.

A remarkable feature of the animals purchased in the expectation of being low yielders is that several of them have turned out to be remarkably high yielders. Ten Beef Shorthorns of the Scotch type were originally purchased but the records of three of these will have to be discarded from the experimental data owing to the fact that they have given over 500 gallons in one lactation. The highest record for a Beef Shorthorn at Shothead is 607 gallons at 3·75 per cent. butterfat in 268 days, calving for the second time within 12 months and then giving 673 gallons at 4·21 per cent. in 225 days.

Pigs.

Particular emphasis has been laid upon the economy of meal consumption per lb. of liveweight gain. The complete litter has formed the basis of our calculations.

Two boars were used. It was found that the progeny of one boar consumed 4·4 lbs. of meal per lb. of liveweight gain and that of the other 3·1 lbs. There was no way of distinguishing between these boars. By carefully weighing both the pigs and the meal it should be possible to reduce the average meal consumption of a herd to around 3·6 lbs. of meal per lb. of liveweight gain. It is, however, questionable whether the additional cost of labour employed in the necessary weighing and measuring is repaid by obtaining the more economical pigs. The cost of labour is an immediate outlay whereas the return on the pigs takes place considerably in the future. As regards the improvement of the pig stock of the country generally in this respect it would be difficult to select for this point without the establishment of Litter Testing Stations.

Sheep.

Inheritance of kemp in Blackface wool.—This work was continued and the first stages completed after the analysis of the samples taken in 1932 (43).

It is possible to extend the conclusions embodied in that paper by stating that the inheritance of kemp percentage in the Blackface fleece depends upon multiple factors, and that certain rams exhibit a degree of homozygosity for high or low kemp content greater than the average, and, in consequence, when mated to an ordinary mixed flock of ewes, will leave progeny which are worse or better than the average for this character. This, expressed in another way, indicates that by consistently selecting stock rams on a basis of low kemp content, breeders have it within their power to reduce the amount of kemp in Blackface wool to negligible proportions. It is of great importance to know that kemp has been shown fundamentally to depend upon genetic factors, since the application of methods of analysis and techniques to other breeds of sheep, such as the Cheviot and the Down breeds, can now be undertaken with less work than would have otherwise been required (8).

It is proposed to describe the results of this work in a further paper, which is to be prepared shortly.

Inheritance of pigmentation and black-spotting.—During the last two years, breeders have shown a return to the preference for Blackface rams with black heads and legs. They assert that dark-faced sheep possess greater hardiness than those with lighter faces, and once more it has become fashionable to use rams with very dark heads.

From the results of our work on the inheritance of coloured fibres in the fleece, and their association with dark-coloured heads, we

are able to predict that the present tendency will have adverse effects on the freedom of the Blackface clip from colour, which will become obvious within the next two to three years.

This illustrates once again that when fashion or some feature believed to be of economic importance demands a change of breeding policy, that change can rapidly become operative, but the possibility of its impact upon the character of the fleece is disregarded.

The last of the series of matings which, so far as we are presently aware, are required to explain the breeding behaviour of black and blue colour in the fleece has been made and the final results will be available during the lambing season of 1934.

Physiology of reproduction.—The first stage of this work has now been completed. The intimate details of structural changes in ovaries, uterus and vagina of the ewe during oestrus have been fully investigated.

Briefly, some of the more important conclusions and implications may be summarised as follows :—

(*a*) Ovulation without oestrus commonly precedes the onset of normal oestrus, and the influence of " flushing " appears to be merely to convert a spurious oestral cycle into one that is normal and fertile (44);

(*b*) Nidation of the fertilized ovum is delayed for as long as 21-24 or more days after conception and during this period the fertilized ovum is especially vulnerable and liable to perish, unless the breeding stock is carefully managed during the first month of pregnancy. This has not been previously recognised (46, 47);

(*c*) During the puerperium there is a complete destruction (desquamation) of the uterine mucous membrane and a subsequent regenerative proliferation. During this phase of desquamation the uterus is comparatively unprotected and is especially liable to infection with septic organisms. This goes far to explain why the death-rate in ewes which have to be given assistance at parturition by shepherds (whose methods for avoiding sepsis are inadequate) is so high. It should be mentioned that this complete desquamation has not been recognised in the cotyledonary type of placentation previously (47).

Lethal and sub-lethal deformities in sheep.—The study of genetic deformities referred to in the previous reports has progressed. That upon which most attention has been concentrated, and which was previously labelled as arthrogryposis (fixation of joints)—can now been defined as *Myodystrophy foetalis deformans*. This name is believed to be more accurate and descriptive of the exact condition encountered. A considerable amount of histological work still remains to be carried out on the numerous tissues and material collected, and this is at present in progress.

Rabbits.

The stock of Rexes has been increased, whilst other types of fur breeds and Angoras are in about the same numbers as last year.

By careful selection in the Rexes, strains have been developed which are in every way as sound as normal coated rabbits. This confirms the suggestion made in the last report.

With reference to the actual fur types, this investigation which has already been in progress for some time is necessarily still incomplete. The evidence so far secured, however, tends to suggest that a finer textured coat is dominant to a coarser type, there also being a tendency in certain instances for does to have coarser fur than bucks. Density of coat seems to be genetically a dominant character, but it is believed that multiple factors are probably also concerned in both these cases.

The question of moult is being studied, and it appears that there is a distinct tendency for protracted moulting periods to be inherited. This, if confirmed by the collection of further data, will prove of considerable importance to rabbit breeders (54).

The genetics of "curly coat" in Rexes is being studied—this type produces a curly coat distinct from any other fur bearing animal, which may be of some economical importance.

The production of new colours in Rex has not been successful this year. One chinchillated Japanese was produced, but unfortunately did not survive. Most new colours are only expected to occur 1/256, so that a large number have to be bred for the production of even a single individual. The stock of F_1s, has, however, been increased for the next breeding season.

Three new varieties are being investigated. One—the Golden Glavcot—has already been adopted as a recognised variety by the National Rabbit Council, whilst two others when established in true breeding lines will probably prove useful additions to the fur bearing rabbits.

Work on Angora wool growth, the genetics of the Smoke Pearl, as well as collection of data regarding litter size, duration of pregnancy and sex ratio is still continuing.

The second case of somatic segregation in the rabbit has been bred from this year, some 100 youngsters being sired by the black-blue Dutch buck. None of his offspring, have, however, shown evidence of inheriting the character.

Sex Physiology.

Clinical research relating to the occurrence of, and the effect of administration of, various hormones in disturbances of the menstrual cycle was carried out.

The experiments on observation of aged rats have reached the end of the first stage. During the past four years more than 4,000 animals were observed from birth to death and at the present

time, the data relating to duration of life, order of dying out, changes in body-weight, organ-weight, etc., with age are being examined.

Data relating to the reproductive life in relation to ageing indicate a complexity much greater than could be expected in view of the findings of previous authors. It appears that testicular function itself becomes impaired in many cases as the animal grows old. It is impossible, however, to restore in any way testicular function by the methods advocated by Voronoff, Steinach and others. It was found, on the other hand, that in the majority of cases testicular function could be restored in senile animals, or the degeneration of the testicle could be prevented by administration of small quantities of gonadotropic hormones, which has to be repeated at short intervals. Administration of these hormones restores testicular secretion and in many cases also spermatogenesis. This finding is in contrast to the response of young animals in which spermatogenesis is not advanced by administration of these extracts.

Libido is not restored in senile animals even though testicular function may be reincited to such an extent that the seminal vesicles, which are indicators of the action of testicular hormone, become actually hypertrophic.

Restoration of gonadic function in the female is less frequently effected by administration of gonadotropic hormones than in the male. Experiments destined to examine the nature of the factors determining reactivity were carried out, and various substances such as the extracts of embryonic tissue, blood from young animals, etc., were examined. It was found that both ovarian and uterine reactivity may be influenced by the addition of extracts in themselves not active.

A number of experiments was carried out in order to determine the nature of the physiological factors responsible for sex drive in the male rat. The experiments confirm the statements of previous authors concerning persistence of sex drive after ablation of both testes, and the absence of sex drive in animals castrated before puberty. It was then found that complete hypophysectomy led to the immediate disappearance of the sex drive whether the testes be present or absent. Restoration of testicular activity by means of gonadotropic extracts administered to hypophysectomised animals need not involve restoration of sex drive, even though hyperactivity of the testes may be induced; whereas extracts of low gonadotropic activity appear to be capable of restoring sex drive. It is concluded that the pituitary has a direct erogenic function, and the existence of an as yet unknown factor regulating the sex drive is suspected.

In addition to work on aged rats, the clinical work and the work on the sex drive, a number of incidental experiments were undertaken involving the study of the pituitary of marine fish for hormone

content, the action of gonadotropic hormones on malignant growth in rats, etc.

Work on purification and preparation of gonadotropic hormones was carried out concomitantly with the other work of the laboratory.

Titles of papers issued during the year.

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23. Greenwood, A. W.: Observations on egg production. *Harper Adams Utility Poult. J.* Report of 17th Annual Poultry Conference, August, 1933.

24. Klemola, V.: The "pied" and "splashed white" patterns in horses and ponies. *J. Hered.*, **24**, 2, 65-69, 1933.
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36. (CROP AND) ANIMAL HUSBANDRY DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Young beef.—The results in connection with the study of various systems of rearing and feeding for the production of young beef referred to in the last report have been published (1). The calves used were from cross-bred Galloway cows by a pedigree white Shorthorn bull. The paper gives an account of different systems of rearing and feeding and detailed comparative costs in the production of young beef under the different systems from the birth of the calves until sold for beef.

Keeping qualities of eggs.—The investigation of factors concerned with the keeping qualities of hens' eggs was continued at the Agricultural Research Institute with the collaboration of the Egg Inspectorate of the Ministry of Agriculture (N.I.). The results obtained during the year under review confirm the conclusions that methods of feeding and management, within reasonable limits, have very little effect on the quality of eggs, judged either by appearance when laid or by the length of time they take to become " seconds " and " rejects." During the summer months, however, appearance and keeping qualities are both markedly inferior to the standard reached in winter. The tests on eggs transported by road and sea through the usual channels of the export trade were repeated and amplified, and yielded interesting results. It was found that transport had a slight deleterious effect on eggs packed with the broad end uppermost and produced a few instances of running air-cells. When eggs were packed with the broad end down a considerable proportion of the eggs had running air-cells (showing a rupture of the shell membranes) and in nearly all cases the air-cell was enlarged and irregular owing to the parting of the outer and inner shell membranes. When eggs were packed lying on their sides, the results observed were intermediate between packing with the broad end up and with the broad end down. Very few of the eggs packed broad end up were recorded as " seconds " after

transport but when packed broad end down a number were "seconds" and a few were "rejects." The keeping qualities of the eggs packed broad end down were reduced to not much more than half the figure for the eggs packed broad end up. A preliminary account of these investigations has been published (2) and it is hoped shortly to publish a full account. The work is being continued and observations are being made on various effects of transport and storage.

Titles of papers issued during the year.

1. Rae, R., and Hale, R. W.: Systems of rearing and feeding for the production of young beef from a herd of cross-bred Galloway cows. *J. Min. Agric. N.I.*, **4**, 1-24, 1933.

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H

DAIRYING

37. NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING.

Husbandry.

The inheritance of milking ability and of the production of butter-fat and milk solids-not-fat.—The collection of data has been continued. Sufficient information has now been accumulated to warrant a detailed analysis with a view to publication.

Calf Feeding.—A trial of an edible soya flour as an ingredient in a calf meal was carried out, extracted soya meal being used as the comparable ingredient in the control diet.

As judged by average daily increases of live weight up to 16 weeks of age, the mixture containing the edible soya flour did not prove quite equal to the mixture containing the extracted soya meal, the latter group increasing in weight by an average of 0·12 lb. per animal per day more than the former.

Causes of removal of cows from dairy herds.—This investigation began in October 1929, and the collection of data ceased on October 1st, 1932. A short summary of the earlier results has recently been published (1). A third interim report dealing with the analysis of the data collected during the year 1931-32 has been prepared and will be published shortly. The records covering the entire three years of the enquiry, and containing detailed information from a population of over 14,000 cows are now being summarised in a single report which is providing useful and unexpected information.

Milking machine investigations.—Work done during the year has included:

(i) Tests of teat cup liners made from rubber prepared by different methods of manufacture, and

(ii) A test of the Gascoigne auto-recorder apparatus.

Manufacture of silage by the A.I.V. method.—During the summer of 1932, with the co-operation of the staff of the Imperial Chemical Industries Research Station about 8 tons of silage was made from lucerne. Observations on the quality and feeding value of this silage during the spring of 1933 indicated that the fodder was poor, and although no mould had developed, a certain amount of decomposition was evident. Dairy cows refused to eat the silage, but yearlings made satisfactory progress whilst eating 12 lb. per head per day for 6 weeks.

Pig feeding experiments.—Two experiments have been carried out to find the relative value of meat meal, fish meal and soya bean meal as protein supplements to a diet of pollards and barley meal for small porkers. The results of both experiments show that as regards gain in live weight, there is no very significant difference in the efficiency of the three protein supplements under the method of feeding adopted. Though the fish meal gives very slightly greater gain of live weight per pig per day, on a somewhat smaller food intake, the food cost per lb. live weight is 6-9 per cent. greater on the fish meal supplement.

The possibilities of using coconut meal as a large ingredient in the ration for porkers were investigated. All animals receiving coconut meal, either ordinary or specially prepared, at a level of 50 per cent. of the ration, scoured to a marked extent and became unsatisfactory in rate of growth and in appearance. Even at a 30 per cent. level the coconut meal was not satisfactory for porkers, the control pens were still superior. The quality of the pork was, however, quite satisfactory.

A comparison of the improvement produced by the addition of increasing quantities of dried full-cream milk to a normal diet for pigs has been made. Whilst all the pigs receiving milk remained well and healthy and showed increased rates of growth, four of the control pigs died toward the end of the experiment. A further experiment is being undertaken to decide, if possible, the cause of death of these control pigs on a diet which is essentially a practical pig-feeding mixture, and why the milk-fed pigs escaped.

Anaemia in suckling pigs.—In 1931 and 1932 death among suckling pigs at this Institute between 1 and 8 weeks old was fairly common. Haemoglobin estimations on over 100 young pigs in 15 litters pointed clearly to anaemia as being one of the most likely causes of death. A practical remedy was begun in 1933 in the use of cinder impregnated with commercial ferrous sulphate, spread on the floor of the styes in small quantities and renewed at fairly frequent intervals. This raised the haemoglobin of the young pigs' blood markedly and prevented further deaths from anaemia.

Husbandry and Chemistry.

A study of typical English milk.—This investigation, begun in October 1928, was concluded in September 1933. A report on the first three years' work has been published (17), and the final period of two years will be covered by a report on somewhat similar lines. It is fortunate that the period included the hot and dry summer of 1933. The effect of this summer is well shown in the daily percentages of solids-not-fat, which had otherwise remained steadily at a fairly high level throughout the four previous years. In the summer of 1933, from late June to early September, the percentages of solids-not-fat reached very low levels, previously unrecorded

for our cows. Ninety per cent. of the evening's samples contained below 8·5 per cent. of non-fatty solids.

The marked changes which take place in some components of milk during the change over from winter feeding to grazing have been further studied. Prof. T. P. Hilditch has published (22) the results of researches on butter made from the milk of our typical herd from 1928-1932, and describes the changes which take place in the component fatty acids of the butter fat when the cows go out to pasture. From the cheese making point of view the property of the milk which shows most distinct modification is the time of coagulation by rennet, which increased by about 30 per cent. between mid-March and the end of May. During this period, however, the changes in titrable acidity, formol titration, pH, ash, total calcium and total phosphorus appear to be insignificant.

Solids-not-fat content of milk.—A large number of monthly records of the solids content of the milk of every cow in the Institute herd for the last ten years has been analysed. The work to be published shortly shows the influence of stage of lactation, level of milk production, number of pregnancies, season of the year, etc., on the solids-not-fat content of the milk.

The nitrogen distribution in 62 samples of whole morning milk covering a range of solids-not-fat content from 6·5 to 9·0 per cent. has been carried out. Samples low in solids-not-fat are characterised also by low total nitrogen, high non-protein nitrogen, low casein nitrogen and high albumin and globulin nitrogen. Some of the results of this work have been published (12).

Methods.—The ever-increasing demands for the determination of total solids in the milk of individual cows used for feeding and breeding have necessitated the introduction of modified methods to economise the space required and time taken for an analysis. The use of small aluminium milk bottle caps as dishes for total solids has economised space, whilst the use of the air-damped balance has economised time. Thus a new rapid and convenient semi-micro technique has been evolved which opens up new possibilities of speed and reduced costs in milk analysis. The method was first described in a paper read before the Agricultural Education Association (July, 1933).

Freezing point of milk.—In all normal as well as all the abnormal milks referred to in previous paragraphs, the freezing point remains very constant (14). The technique of this valuable test has been intensively studied during the past year, and a new apparatus designed by Dr. Monier Williams has been used successfully. The variations in the freezing point of the milk of the " typical herd " still fall almost within the narrow limits of accuracy of the present apparatus.

Calcium and phosphorus changes in cows' blood.—In collaboration with W. L. Little, F.R.C.V.S., an investigation of changes

in the calcium and diffusible calcium, and of the phosphorus content of cows' blood during the feeding of cod-liver-oil and at parturition, has been undertaken. The results have been published in part (21).

The phosphorus compounds of milk, and the phosphatase of milk and butter.—Both the milk of individual cows and herd milk have been investigated. A fairly satisfactory method for determining the phosphorus partition in cows' milk has been devised, and it has been found that the " ester phosphorus " of the milk varies with the breed of cow. An active phosphatase is present in all samples of raw milk, and brings about changes in the ester phosphorus content of the milk on standing. The properties of this enzyme have been examined. It has been found to be present both in raw milk and in butter made from raw cream, but absent from properly pasteurised milk or butter made from pasteurised cream. Its absence from a sample of milk or cream indicates with a fair degree of certainty that the milk or cream has been heated sufficiently to destroy such pathogenic organisms as were originally present.

Nutritional value of raw and heated milk.—This work has been brought to a conclusion, and the results are being prepared for publication.

The vitamin content of type milk as affected by the season and the nutrition of the cow.—A two years' study has just been completed, and the results are being subjected to statistical analysis.

The antirachitic activity of butter.—This has been investigated more closely, and it has been found that there is in butter in addition to vitamin D (in the strict sense) a novel factor or property capable of curing experimental rickets in rats but unlike the classic vitamin D, not recoverable in the non-saponifiable residue (19). This point may have a bearing on the value of butter (and milk) as a source of vitamin D in human nutrition.

Chemical estimation of vitamin A and carotene.—Work in this field has recently been published (8, 23). Data are presented in these papers giving the quantitative changes in the concentration of carotene and vitamin A in butter throughout the year. The substance (or substances) mentioned in the previous report present in butter and inhibiting the antimony trichloride reaction has been found to be subject to seasonal variations, being present in much larger concentration in summer than in winter butter fats. Blue values determined on untreated butter fat are useless as a guide to vitamin A content. For this purpose the determination should be carried out on the non-saponifiable matter. Most of the work mentioned in this paragraph has been done in collaboration with the Nutritional Laboratory, Cambridge.

Chemical estimation of vitamin C in milk.—The Tillmann-Harris chemical test for vitamin C (using the 2 :6 dichlorophenol-indophenol indicator) has been applied to milk and it was found

that the concentration in milk of the factor (in all probability vitamin C) responsible for the reduction of the indicator is subject to marked and irregular variations. Sometimes a relatively high initial potency observed in milk immediately after milking may be completely lost in the course of a few hours. It was later found that the variations were largely due to the destructive action of light. A note on the subject has been published (18). Results of the work on the action of light and micro-organisms on the reducing factor have also been published. Owing to the pressure of other work it is unfortunately not possible at present to carry this interesting work much beyond the preliminary stage but its practical importance seems obvious. It should be pointed out that any future work upon the stability of the labile factor (vitamin C) in milk to physical and chemical agents such as heat or oxidation must take account of the complicating factor of destruction by light.

Comparative study of the vitamin content of milk of different breeds of cattle.—The colour and vitamin A content of the butter of Guernsey and Shorthorn cows have been compared. The butters were obtained from cows of both breeds receiving the same ration of concentrates and grazing in the same fields. The Guernsey butters were, as expected, much yellower than the Shorthorn butters and contained about three times the amount of pigment (chiefly carotene) as measured in the Lovibond Tintometer. On the other hand their vitamin A content (measured on the non-saponifiable matter by means of the antimony trichloride test) was lower than that of Shorthorn butters. The total vitamin A activity (vitamin A and carotene) was found in biological experiments to be identical for both butters. A preliminary report is being published.

Study of abnormalities occurring in experimental rats.—The study mentioned in the previous report has been continued in collaboration with Prof. Crew. The abnormality was found to be due to a monogenic autosomal recessive lethal and a paper describing this, the first lethal factor to be observed in the rat, has been published (24).

Metallic contamination of dairy products.—The mode of combination and the distribution of traces of heavy metals in the different phases of milk and milk products have been investigated. It was shown that the ionic activity of the contaminating metallic compound is of a low order of magnitude but that acid conditions increase the amount in the ionic state. Based on the ratio of metal to protein nitrogen it has been deduced that the proteinates of the heavy metals are preferentially adsorbed at the serum-fat globule interface irrespective of whether the emulsion is an O-W or a W-O type. The metal is thus concentrated in centrifuged cream and in butter, at the site where fat deterioration mostly occurs, namely, the fat-serum interface (11).

The effect of the wrapping material on the fat of fatty foods.—The copper and iron content of vegetable parchments of various descriptions from several home and continental manufacturers showed marked differences from one sample to another, but the apparently large contents of heavy metals in such parchments did not seem to add to the susceptibility of fat, in contact with the material, to autoxidise. Deeply coloured cellophanes of various tints were found equally efficacious in preventing autoxidation of melted butter fat, or the fat in biscuit meal, during exposure to strong sunlight for 168 hours. Lightly tinted or colourless wrappings were less effective.

Diacetyl in butter.—Various methods for the determination of diacetyl in butter have been tried. The method finally adopted gave quantitative recovery of small quantities (1 p.p. million) of diacetyl added to butter. Amounts of diacetyl varying from 0·2 to 1 p.p.m. have been found in fresh butter of home origin made from ripened cream. No diacetyl has been found in Dominion butter made from neutralised cream.

"Fishiness" in butter.—Experiments are in progress on the part played by diacetyl in the development of fishiness in butter.

Molassed beet pulp.—The work outlined in the previous report has been continued, and methods of betaine and trimethylamine analysis have been extended to milk. Small quantities of trimethylamine occur in milk after feeding molassed by-products, but 4 lb. of beet molasses or 10 lb. of molassed pulp per day fed in two equal portions did not cause a fishy taint in the milk of the experimental animals.

Whey silage experiments.—Experimental silage from grass mowings, long grass and lucerne has been made both at the Institute and at the Imperial Chemical Industries farm at Jealotts Hill, and at two other centres using fresh whey, dried whey or solutions of dried whey with or without inoculation by lactic acid organisms, as preservative. The product is palatable for cows and pigs and makes a very satisfactory feed, retaining much of the mineral and nitrogenous constituents of the whey, otherwise wasted. Further experimentation is in progress, but there is little doubt that very satisfactory silage can be made in this manner, and a possible outlet for surplus whey is indicated.

Bacteriology.

Cheese—ripening of hard cheese—lactic acid bacteria.

Growth and metabolism of lactic acid bacteria.—There is reason to believe that some strains of these bacteria when freshly isolated from cheese have a cell size and fermentative vigour which disappears on subculture.

In order to put the knowledge of their biochemical activities in milk and milk products on a sounder foundation an extensive investigation is in progress of the respiration and metabolism of the lactic acid bacteria. The type of respiration of these organisms is being studied by manometric methods. Evidence of considerable value for the purposes of species identification has been obtained. Media able to inhibit certain strains of streptococci but to permit the growth of other streptococci or lactobacilli have been prepared.

Cheese ripening.—Pure cultures.—An adequately representative group of lactic acid bacteria from Cheddar cheese has been tested for peptonising ability on milk (*a*) alone, (*b*) with filtered, sterile rennet, (*c*) with ordinary rennet. The activity rises from (*a*) to (*c*).

With a view to finding out the role (if any) of the enzymes pepsin and rennin in cheese itself, cheese have been made with rennet solutions in which either pepsin or rennin has been destroyed by suitable treatment. Although the clotting of milk takes appreciably longer when rennin is destroyed, no significant differences in the rate of ripening occur.

Red spot.—It has been shown that *L. Rudensis* which causes rusty spot in cheese can only produce its pigment at an Eh more negative than —0·1 volts (at pH 5). If it were possible to maintain the interior of the cheese at an O.R. potential greater than this the rusty spot problem might be solved, and an endeavour has been made to do this using KNO_3 and $KClO_3$. None of the 5 experimental cheese containing oxidant showed red spot, whilst it was present in 4 out of 5 control cheese (without oxidant).

Milk.

Carbolic taint of commercial sterilised milk.—The antigenic relationships of the three forms of the causative organism have been investigated, with particular regard to the H and O antigens. The results have not yet been interpreted. The organism is still unidentified. Preliminary serological tests to establish a possible relationship to other spore-formers both aerobic and anaerobic showed no agglutination between its serum and suspensions of *B. subtilis*, *B. megatherium*, *Cl. sporogenes* and *Cl. histolyticum*. An interesting variant, of which the production appears to be bound up with the reorganisation of the cell contents during sporulation, is completely unable to form spores, probably due to the loss of a fundamental character during this reorganisation.

Bovine tuberculosis—the Vernes test.—This work has been continued, and the results indicate no distinction between normal, reactor and known tubercular sera when tested according to Vernes' formula. None of various modifications tried have yielded any better results.

Viability of bovine tubercle bacilli.—In the cold wet summer of 1931 the viability of bovine tubercle bacilli in dung and soil proved

to be 178 days when exposed to full sun and air. In 1932, a typical summer, it was 153 days.

Guinea pigs allowed to run in the open and feed on grass which had been infected with the bovine tubercle bacillus, failed to become infected, although virulent tubercle bacilli were recovered from the grazed area after they had been removed (29).

Experiments are in progress to find whether guinea pigs and calves can be infected with bovine tubercle bacilli by feeding on grass infected at intervals with virulent cultures. For this purpose the animals have been divided into two groups. One group is kept under cover and fed daily with cut infected grass, the other is allowed to run in the open and graze on the infected grass, which is re-infected at regular intervals.

High-temperature-short-time pasteurisation.—The performance of a plate type of high-temperature-short-time pasteurising plant has been very thoroughly examined, using in most cases milk of very poor hygienic quality. Tests were made before and after pasteurisation for numbers of viable bacteria, creaming capacity, methylene blue reduction, keeping quality, palatability and efficiency of the destruction of pathogenic organisms.

It appears that the process investigated, when properly carried out, provides a product of good creaming capacity, low bacterial count, good keeping quality, and good palatability. In spite, however, of the apparently good performance, it is felt that this process does not give the margin of safety that is provided by well controlled holder processes.

Sterilisation of milk by ultra-violet light.—An experimental plant, using a mercury vapour lamp and a film of milk 0·134 mm. in thickness, was investigated. Usually the reduction in bacterial count after passing the steriliser was satisfactory, but occasionally no more than an 80 per cent. reduction was obtained. Exposure for too long a time results in taints due to fat oxidations.

Milk and serum proteins.—Preparations of pure casein, serum albumin, pheudo-globulin and euglobulin have been made. In the course of this work an ultra filter in stainless steel has been designed (26). By its aid sterile culture media can be prepared without the application of heat and proteins can be purified by filtration through " cellophane."

Physiology.

Nutritional requirements for lactation.—On account of shortage of accommodation, development of the investigation of this problem has been restricted. Confirmation of the earlier results has been obtained, a fairly constant high proportion of the rats which received the experimental diet having failed to lactate though they appeared to be normal in all other respects. The rats in the stock colony have shown little or no lactational failure.

Studies on milk secretion and its relation to blood composition.—Continuation of this work has confirmed the conclusion reached previously that the ratio of solids-not-fat to fat in milk is correlated with the ratio of sodium to diffusible calcium in the blood. It is significant that no such correlation has been observed for the ratios of sodium to non-diffusible calcium or sodium to total calcium in the blood, in both of which the calcium is in a form that is probably inactive physiologically. A paper on the subject is now in the press. The differences in composition of the milk of different breeds is being studied from this point of view.

In the case of cows receiving various experimental rations no significant variations in the blood have been observed. Two animals in this group received cod-liver-oil in the diet and although the solids-not-fat : fat ratio of the milk rose markedly owing to depression of the butter fat percentage, little significant change occurred in the sodium : diffusible calcium ratio of the blood. Attempts that have been made to vary the blood composition by injection of calcium compounds have produced only transitory changes.

Secretion of milk proteins.—A study is in progress of the chemical and immunological relationships between the proteins of blood and of milk.

Blood composition.—Data concerning the composition of the blood of cows is being collected in respect of several other constituents in addition to those mentioned.

A method of low-pressure ultrafiltration, using standardised collodion tubes and controlled constant pressure (32, 34) has been devised. It is being applied to the study of ultra-filtrable calcium in the blood. The precision of the methods marks a distinct step in the present-day technique of attacking problems of ultrafiltration.

Solids-not-fat content of milk.—A report on cows giving milk poor in solids-not-fat has been prepared and a paper has been published indicating that pathological conditions of the udder may have been responsible for the poor quality of the milk, causing dilution of a normal secretion in the udder by a fluid of the nature of oedema fluid (37).

Titles of papers issued during the year.

1. Bartlett, S.: The causes of removal of cows from dairy herds (1929-31). *Agric. Prog.*, **10**, 154-6, 1933.
2. Mackintosh, J.: Biennial reviews of the progress of dairy science. Feeding standards for dairy cows. *J. Dairy Res.*, **4**, 165-170, 1932.
3. ————: The variation of fat content of milk. *Berks. Farmers' Yr. Bk.*, 51-58, 1933.
4. ————: The eradication of tuberculosis from dairy cattle. *Vet. J.*, **89**, 171-175, 1933.
5. ————: The proving of sires—bull index systems. *Island Cow*, 19, 461-462, 1933.
6. ————: The importance of butterfat testing. *Dairy Shorthorn J.*, **2**, 193-196, 1933.

7. Mackintosh, J.: Dairy farming and dairy work. Farmers' Guide to Agricultural Research in 1931, 1-23, 1932.
8. Booth, R. G., Kon, S. K., et al.: A new variable factor in butter fat. *J. Soc. Chem. Ind.*, **52**, 12, 269, 1933.
9. Davies, W. L.: The distribution of nitrogen in milk with reference to the solids-not-fat content. *J. Dairy Res.*, **4**, 142-146, 1932.
10. ————: Metallic contamination in processing. *Milk Ind.*, **13**, 9, 55, 1933.
11. ————: The mode of combination and distribution of traces of heavy metals in dairy products. *J. Dairy Res.*, **4**, 255-264, 1933.
12. ————: The composition of the "isotonic diluent" in samples of milk low in solids-not-fat. *Ibid.*, **4**, 273-278, 1933.
13. Foot, A. S.: Meal values for small porkers. Reading experiment in search of protein supplements—live weight gains. *Farmer and Stock-breeder*, 2261, 1443-1444, 1933.
14. Golding, J.: The freezing point—is it specific for pure fresh milk? *J. Brit. Dairy Farmers' Assoc.*, **45**, 58-67, 1933.
15. ————: Amyl alcohol for milk testing. *Analyst*, **58**, 531, 1933.
16. ————: Requirements of fattening pigs for vitamin B complex. *Pig Breed. Ann.*, 1933-34.
17. Golding, J., Mackintosh, J., and Mattick, E. C. V.: Investigations on the milk of a typical herd of Shorthorn cows. I. *J. Dairy Res.*, **4**, 48-73, 1932.
18. Kon, S. K.: Lability of the "reducing factor" (vitamin C?) in milk. *Nature*, **132**, 64, 1933.
19. Kon, S. K., and Booth, R. G.: A chemical difference between anti-rachitic factors from different sources. *J. Soc. Chem. Ind.*, **52**, 19, 420, 1933.
20. Mattick, A. T. R., and Kon, S. K.: Influence of certain agents on the lability of the "reducing factor" (vitamin C?) in milk. *Nature*, **132**, 446, 1933.
21. Mattick, E. C. V., and Little, W. L.: The calcium content of cows' blood. I. The effect of feeding cod liver oil. *Vet. Rec.*, **13**, 238-245, 1933.
22. Dean, H. K., and Hilditch, T. P.: Some further observations on factors which influence the component fatty acids of butter. *Biochem. J.*, **27**, 889, 1933.
23. Booth, R. G., Kon, S. K., Dann, W. J., and Moore T.: A study of the seasonal variation in butterfat. I. Seasonal variations in carotene, vitamin A, and the antimony trichloride reaction. *Ibid.*, **27**, 1189, 1933.
24. Crew, F. A. E., and Kon, S. K.: A lethal in the rat. *J. Genet*, **28**, 1, 25, 1933.
25. Davis, J. G., and Mattick, A. T. R.: Studies in the metabolism of the lactic acid bacteria. I. Nitrogen metabolism. *J. Dairy Res.*, **4**, 81-90, 1932.
26. Folley, S. J., and Mattick, A. T. R.: A stainless steel high pressure ultra-filter. *Biochem. J.*, **27**, 1113-1115, 1933.
27. Hiscox, E. R., Hoy, W. A., Lomax, K. L., and Mattick, A. T. R.: The bacteriological examination of milk. I. Modification of the agar plate count method. II. The use of the methylene blue reductase test at 15·5°C as a method of determining the keeping quality of milk. *J. Dairy Res.*, **4**, 105-21, 1932.
28. Kon, P. M.: Coliform organisms in milk and bovine faeces. *Ibid.*, **4**, 206-12, 1933.
29. Maddock, E. C. G.: Studies on the survival time of the bovine tubercle bacillus in soil, soil and dung, in dung and on grass, with experiments on the preliminary treatment of infected organic matter and the cultivation of the organism. *J. Hygiene*, **33**, 103-17, 1933.

30. Mattick, A. T. R., Hiscox, E. R., and Christian, M. I.: Biennial reviews of the progress of dairy science. B. Bacteriology and mycology applied to dairying. I. Technique of milk examination. II. Saprophytic flora of milk and milk products. III. Pasteurisation of milk. IV. Butter. V. Cheese. *J. Dairy Res.*, **4**, 285-316, 1933.
31. Kay, H. D., and Guyatt, B. L.: Experimental rickets as a phosphorus deficiency disease. *Nature*, **131**, 468, 1933.
32. Folley, S. J.: A method of low pressure ultra-filtration. *J. Soc. Chem. Ind.*, **52**, 12, 270, 1933.
33. ———: A note on the preparation and fractionation of the a-naphthyliosocyanate compound of plastein. *Biochem. J.*, **27**, 151-2, 1933.
34. Folley, S. J., and Peskett, G. L.: Automatic pressure control. *J. Physiol.*, **78**, 2, 13-14P, 1933.
35. Peskett, G. L.: Biennial reviews of the progress of dairy science. The physiology of dairy cattle. Growth. *J. Dairy Res.*, **4**, 154-156, 1932.
36. ———: Growth factors of lower organisms. *Biol. Rev.*, **8**, 1-45, 1933.
37. Peskett, G. L., and Folley, S. J.: Some observations on cow's milk poor in non-fatty solids. *J. Dairy Res.*, **4**, 279-84, 1933.

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38. HANNAH DAIRY RESEARCH INSTITUTE.

Nutrition.—Considerable progress has been made in the investigation of the comparative value of the proteins of various foods for milk production. This work was undertaken in order to ascertain how far the quality, as distinct from the quantity, of protein is a factor of importance in the nutrition of milking cows. With this object in mind amino-acid analyses of a number of typical home-grown and imported foodstuffs have been made, and it has been found that many concentrates normally used in the rations of milking cows are seriously deficient in certain amino-acids, such as lysine and tryptophane, which are essential constituents of the milk proteins. In order to determine how far such amino-acid deficiencies result in a poor utilisation of food protein, special feeding trials have been undertaken with dairy cows. These trials have been carried out in specially devised stalls in which it is possible to ascertain the exact relation between intake and output of food constituents, and thus to determine the efficiency with which a ration can be utilised. In the first series of trials a comparison was made of the values for milk production of linseed, meat meal, and bean meal. The results demonstrated the high wastage which occurred when linseed was used as a source of protein, as compared with the efficient utilisation when bean meal was fed (1). In the second series, designed to compare the nutritive values of the proteins of earthnut cake and of a poor quality mixed ration with those of pea meal and blood meal, the very marked superiority of the latter foodstuffs—and particularly of the blood meal—was demonstrated (2). Moreover it was found that a very close correlation existed between the lysine (and in one instance the tryptophane) content of the food protein and its biological value, as calculated by a specially devised formula, indicating that poor

utilisation was due to a definite amino-acid deficiency. The results also showed that, with the poorer quality proteins, the animals utilised their own body tissues in an attempt to maintain normal milk yields, as shown by the high creatine, and the S : N ratio of excess sulphur and nitrogen, excreted during the deficient protein feeding periods. Work of this nature is now being extended to include the amino-acid requirements for maintenance, as well as for milk production.

Lactation.—During the year further progress has been made in elucidating the precursors of the individual milk constituents. Particular attention is at present being given to the fat metabolism of the mammary gland and to the influence of the phosphorus compounds of the blood on the secretion of milk. In the latter connection further studies have been made into the action of proteolytic enzymes on phospho-proteins.

Genetics of dairy cattle.—In the previous work on this subject, which concerned the genetic construction of the Ayrshire breed and the degree of inbreeding practised, it was found that the so-called " short " method of determining the coefficient of inbreeding gave results which were at variance with those obtained by the " long " method. A careful investigation into the cause of this discrepancy is at present in progress, and the work is being extended to study the breeding methods adopted by owners of vessel-bred and milk-bred stock respectively.

Crop and stock husbandry.—Apart from the more strictly scientific problems outlined above, investigations are continually in progress on the farm with the object of testing new methods of crop and stock husbandry.

An investigation has been made into the yields of closely-cut growing herbage obtained under the favourable climatic conditions of the south-west of Scotland. The object of this work was to ascertain whether, with the larger yields which it was anticipated would be secured, the artificial conservation of young grass could be placed on an economic basis. Previous results obtained in the south of England had given only moderate yields, i.e., about $3\frac{1}{2}$ tons of dried grass per acre per season from intensively manured plots. The Institute's investigations, carried out on duplicate plots each of one-fortieth acre, gave yields in two successive years of about 3 to $3\frac{1}{2}$ tons per acre per season from un-manured plots, while the yields from intensively manured plots approximated 6 tons. The work is being continued for a third year in order to study the effect on the herbage of continuous cutting over a period of years.

Extensive studies relating to the construction and equipment of cattle byres have now been in progress at the Institute for three years. The essential features in the construction of byre flooring have been determined, and the details of a new design of floor have been published (3). A second paper, dealing with the construction of automatic water bowls, has also been published (4).

In addition, practical trials are being made into the relative efficiency of different types of milking machines, and into other practical problems involved in the production of clean milk.

Bovine tuberculosis.—The formulation of methods for controlling the spread of bovine tuberculosis among dairy herds constitutes one of the most urgent problems of the dairy industry. During the past four years an intensive study of this subject has been made at the Institute. The problems involved are two-fold : first, to determine the present incidence of the disease among stock, and the extent to which the milk supply is infected, and second, to investigate the means by which bovine tuberculosis might be quickly and economically eradicated from dairy herds.

With regard to infection among stock, a large number of tuberculin tests have been carried out on random dairy herds. The results not only show that a high degree of infection exists in such herds, but indicate that existing legislative measures, such as the Tuberculosis Order, are quite ineffective in preventing the spread of the disease (6).

With regard to milk infection, the investigation into the infection of the Scottish milk supply, which was referred to in the last Report, and which has been carried out in conjunction with the Department of Health for Scotland and with the Public Health Departments of Edinburgh, Glasgow, Dundee and Aberdeen, has now been completed and the results published (5).

The experimental tuberculosis eradication scheme, which has been financed by the Medical Research Council and which has been in progress for three years, has now been terminated (6). The only incentives given to the thirty owners who participated in the scheme were the provision of free tuberculin testing and of free advice on methods of isolation and on the rearing of tubercle-free young stock. The final results show that 20 out of 28 herds which adopted the suggested eradication methods were clear of infection after 3 years' testing, while the number of reactors in the remaining 8 herds was reduced from an average of 52 per cent. to an average of 24 per cent. In two other herds included in the scheme, in which no proper precautions were taken to limit the spread of infection, the proportion of reactors increased from 42 per cent. to 58 per cent. As noted in last year's Report, the results of the experimental scheme have clearly demonstrated the feasibility of reducing the incidence of tuberculosis among dairy cattle by the provision of relatively small incentives to the herd owner.

Milk fever.—Although in the past much work has been devoted to the aetiology of milk fever, and although a new method (i.e., calcium therapy) has been devised for the treatment of this condition, the underlying cause of the disease is not yet clear. In an endeavour to elucidate the factors involved, it was decided to study in detail the metabolic reactions of the ruminant immediately prior

to and following parturition. The results of this investigation show that the pituitary gland plays an important role in parturition, the internal secretions from this gland being capable of causing profound metabolic disturbances (7). Subsequent to this work, a method has been devised at the Institute by which the oxytocic principle in the blood can be estimated with considerable accuracy, and this method has now been applied to pregnant animals and to cows immediately pre-partum and post-partum.

The pasteurisation of milk.—Until the raw milk supply of the country is produced and handled in such a way as to avoid the risk of milk-borne infection, the process of pasteurisation is likely to be extensively employed as a safeguard against tuberculosis and other milk-borne diseases. The value of properly controlled pasteurisation as one method of reducing the tuberculous infection of milk has been referred to above. The adoption of pasteurisation has, however, been criticised on the ground that the heat treatment of the milk seriously reduces its nutritive value. In order to determine how far this criticism is valid, a careful review has been made of all available literature on the subject. This review has now been published (10). The conclusions of the review indicate that, while the nutritive value of raw milk may be slightly impaired by pasteurisation, the deficiency may be made good by the addition of small quantities of vitamin concentrates.

In addition a preliminary study has been made of certain economic aspects of compulsory pasteurisation. The results of this study give good grounds for the belief that the adoption of compulsory pasteurisation would not affect either producers' or consumers' prices, though it would probably eliminate the casual producer-retailer and would seriously embarrass the position of the small milk dealer (11).

The condensing and drying of milk.—In the previous report reference was made to an investigation into the factors controlling the solubility of milk powders, and it was pointed out that these factors are three-fold, i.e., temperature of heating, time of heating, and concentration of milk solids. Further work has now been carried out to ascertain how far solubility determinations can be used as an index of the thermal conditions existing in a commercial milk drying plant (12). The results demonstrate the great importance of temperature of reconstitution in the determination of solubility, and indicate that, by choosing suitable reconstitution temperatures, valuable information can be obtained regarding plant conditions.

As regards condensed milk, careful studies have been made into the reactions underlying the heat coagulation of milk proteins. The effect of heat on the cleavage of phosphorus and nitrogen from casein, and the alkali-combining capacity and coagulability of the resulting protein compound, have been determined, and the relation

of these reactions to the heat coagulation of milk have been investigated. The results of this work will shortly be published. In addition certain physico-chemical properties of highly concentrated milk solutions have been determined. A paper dealing with the elevation of the boiling point of such solutions, with and without the addition of sucrose, has been published (13).

Titles of papers issued during the year.

1. Morris, S., and Wright, N.C.: The nutritive value of proteins for milk production. I. A comparison of the proteins of beans, linseed, and meat meal. *J. Dairy Res.*, **4**, 177, 1933.
2. ————: The nutritive value of proteins for milk production. II. A comparison of the proteins of blood meal, pea meal, decorticated earth-nut cake, and a mixture of decorticated earth-nut cake and flaked maize. *Ibid.*, **5**, 1, 1933.
3. Fowler, A. B.: The construction and equipment of cattle byres. I. Byre flooring. *Scot. J. Agric.*, **16**, 191, 1933.
4. ————: The construction and equipment of cattle byres. II. Automatic water bowls. *Ibid.*, **16**, 314, 1933.
5. Scottish Department of Health: Tuberculous infection in milk. *Sp. Rep. Ser. Med. Res. Counc. Lond.*, No. 189, 1933.
6. Jordan, L.: The eradication of bovine tuberculosis. *Ibid.*, No. 184, 1933.
7. Morris, S.: Metabolism during parturition. I. General metabolism. *Brit. J. Obstetrics Gynaec.*, **40**, 230, 1933.
8. ————: Metabolism during parturition. II. Metabolism following injection of posterior lobe extracts. *Ibid.*, **40**, 580, 1933.
9. ————: Metabolism during parturition. III. Influence of posterior lobe extracts on water metabolism. *Ibid.*, **40**, 597, 1933.
10. Stirling, J. D., and Blackwood, J. H.: The nutritive value of milk in relation to pasteurisation. A review of existing knowledge. *Hannah Dairy Res. Inst., Bull.* **5**, 1933.
11. Wright, N. C.: Some implications of compulsory pasteurisation. *Brit. Assoc. Adv. Sci., Leicester*, 1933.
12. Howat, G. R., and Wright, N. C.: Factors affecting the solubility of milk powders. II. The influence of temperature of reconstitution on protein solubility. *J. Dairy Res.*, **4**, 265, 1933.
13. Scott, A. W.: The boiling point elevation of concentrated milk solutions. *J. Roy. Tech. Coll., Glasgow*, January, 1933.

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39. DAIRY BACTERIOLOGY DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

The work of this Division has been principally confined to problems of a routine nature in connection with the administration of the Sale of Milk Act (N.I.), 1927. Investigations were continued on the problem of improving the quality of butter and cream produced by creameries.

I

AGRICULTURAL ECONOMICS

40. AGRICULTURAL ECONOMICS RESEARCH INSTITUTE, OXFORD UNIVERSITY.

The dairying industry.—The establishment of the Milk Marketing Board has increased the need for further study of the economics of dairying. In the past few years most of the dairying investigations of the Institute have been directed towards the collection of information upon the methods of milk distribution. In the current year a pamphlet was issued (6), describing the results of a survey of butter-making in West Cornwall, where a large number of farmers are dependent mainly upon the production of milk for butter-making.

Studies of the cost of milk production published from time to time have always shown a marked degree of diversity in the expenditure upon labour, upon feeding-stuffs, etc., which could not always be explained by the particular circumstances of individual producers. Under the auspices of the Advisory Economists' Committee, therefore, an investigation of the cost of labour and foods in milk production has been organised with the object of providing standards of measurement of individual efficiency as a means to raising the general standard.

While the improvement of the standard of dairy herd management under established systems of farming is one line of research, the examination of new methods is also of importance. In last year's Report reference was made to a survey then in progress of farms on which the travelling milking-bail was in use; the report (5) of this survey contains a full discussion of the capitalisation of dairying under the system, of experiences on different types of soil, of the different methods adopted for herd replacement, of the cost of fencing and watering pastures, of labour organisation, and of other questions of importance. The general conclusion is that there is no doubt of the economy in milk production by this system, given certain conditions. The complement to the investigation of milk production and distribution in this country is provided by the work on the seasonal variations in the prices and supplies of Dominion and foreign dairy products. This work is still in progress.

The sugar beet industry.—The approaching end of the original period of the home-grown sugar subsidy has been made the occasion of a review of growers' experiences over ten years, and the Institute will shortly issue a comprehensive report.

The study of farming systems.—For some years past it has been the practice to examine and report upon notable individual achievements in farming where some new principle of management seemed to have been evolved. The seventh of the studies in this series was completed and published (3). It is an account of the stages by which an arable farmer in the Midlands introduced a fairly complete revolution in his practice in a successful effort to keep abreast of changing economic conditions.

Of a different type is a farm in Worcestershire where mass-production methods are being applied on a large farm to the growing of market-garden crops. The Director is making a study of the development of this business for the purposes of a report.

Price studies and statistics.—Mention has been made of the statistical and price studies of imported dairy products. Dr. Murray has also continued his examination of pig prices, particularly the relation of feeding-stuffs prices to the fluctuations in the production and prices of pigs. An article by him on this subject was published (21). An investigation was made of the formula proposed by the Reorganisation Commission for Pigs and Pig Products as a basis for guaranteed prices, and the formula was subsequently amended. Statistics of agricultural imports are compiled and kept up to date for reference, and a digest of the various regulations for the restriction of imports under the Ottawa Agreements, and of the voluntary agreements and the trade agreements with various specific countries, are among the other activities of this branch of the Institute's work.

Costing and accounts.—The study of farming by agricultural costing and the analysis of financial accounts has been a feature of the Institute's work since it was founded. The collection of agricultural costs for a small number of mixed farms is valuable for the supply of information on general labour costs, the cost of tractors and machinery, and the cost of crops, the results of which are published from time to time in the Institute Quarterly, *The Farm Economist*. For four years past the accounts of a group of poultry farms have been kept, to compare costs and financial results under different systems of management, such as poultry-keeping as an adjunct to mixed farming and as a specialised business. A report is in course of preparation.

7. *Rural Migration.*—A sociological study of considerable interest (7) has been published. It shows that there has been a continuous migration eastwards of farmers, mostly the working type, from the western and south-western districts of England, from Wales, and from south-west Scotland, where the proportion of small farms is well above the national average, extending back for more than half a century.

Titles of papers issued during the year.

(a) BOOK.

1. Murray, K. A. H. (in collaboration with Viscount Astor).: *The planning of agriculture.* Oxford Univ. Press; London, Humphrey Milford, 1933.

(b) PAMPHLETS.

2. Orwin, C. S.: *Financing the farmer: a scheme to provide short-time credit for farmers.* Oxford: Clarendon Press. London: Humphrey Milford, 1933.
3. Bridges, A.: *Progress in English farming systems.* VII. *The flexibility of farming. Ibid.*, 1933.
4. Bridges, A., and Upfold, S. J.: A simple system of farm book-keeping. *Min. Agric. Bull*, 58 (3rd Edition), 1932.
5. Dixey, R. N., and Messer, M.: *Open air dairying. A survey of farms using milk bails in* 1932. Oxford: Clarendon Press, 1933.
6. Prewett, F. J.: *Manufacturing milk. Ibid.*, 1932.
7. Smith, E. Lorrain: *Go east for a farm. Ibid.*, 1932.
8. Twentieth Annual Report and List of publications. *Agric. Econ. Res. Inst., Oxford*, 1933.

(c) ARTICLES AND ADDRESSES.

9. Orwin, C. S.: The countryside (from "Professors of foresight: a symposium"). *Listener*, 21st December, 1932.
10. ————: New state policy for agriculture. *Yorks. Post Trade Rev.*, 12th January, 1933.
11. ————: Farming to meet the times. *Scot. J. Agric.*, **16**, Jan., 1933.
12. ————: British wheat. *Farm J.*, Philadephia, U.S.A., January, 1933.
13. ————: World agriculture. *Nineteenth Century and After*, March, 1933.
14. ————: Towards land purchase. *Countryman*, April, 1933.
15. Bridges, A.: A change of method that paid. *Farmer and Stockbreeder*, July, 1933.
16. ————: Some economic aspects of grassland. Brit. Assoc. Meeting, Leicester, September, 1933.
17. Dixey, R. N.: Das britische Weizengesetz. *Berichte über Landwirtschaft*, February, 1933.
18. Murray, K. A. H.: Quarterly notes on prices and supplies. *Pig Breed. Gaz.*, November, 1932; February, June, August, 1933.
19. ————: A survey of the prices of pigs and feeding stuffs in England and Wales during 1932. *Nat. Pig Breed. Ann.*, 1933.
20. ————: Der Markt für Schweinefleisch und Bacon in Grossbritannien. *Blätter für landwirtschaftliche Markt-forschung*, May, 1933.
21. ————: The future development of the pig industry in Great Britain. *Empire J. Exp. Agric.*, September, 1933.
22. Prewett, F. J.: Consumers' preference: Beef weights and prices. *J. Min. Agric.*, **40**, June, 1933.
23. ————: Towards an agricultural policy. (In collaboration with Mr. Christopher Turnor). *Country Life.*
24. Staff of the Institute.: Recent advances in agricultural economics. *Agric. Prog.*, **10**, 7-21, 1933.

(d) PERIODICALS.

25. Occasional notes, **1**, 20.
26. Farm economist, **1**; 1, 2 and 3.

41. FARM ECONOMICS BRANCH. DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

The economic position of agriculture in Scotland.—The third report on the profitableness of farming in Scotland giving the financial results obtained on certain groups of farms in Scotland during 1930-31 has been published (1). This forms the third of a series dealing with the economic position of the agricultural industry in Scotland, the aim of which is to provide information of value to farmers, factors, proprietors and others interested in the practical use of land for economic purposes; to teachers of agriculture and county staffs responsible for giving guidance to the farming community; and to administrators and men in positions of responsibility in the guidance and formation of opinion upon agricultural affairs. They present a survey of Scottish farming with particular reference to the factors underlying differences in profits, describe the economic organisation of the farms, and pay special regard to the labour and capital requirements. The reports also deal fully with the underlying causes of the variations in annual profits such as areas and yields of crops, turnover of live stock, changes in price levels and resultant changes in standards of living on the farm.

Marketing of agricultural produce.—A report on the marketing of potatoes in Scotland has been published (2). The statistical data therein provided are sufficient to allow of a fairly exact quantitative measure being made of all the factors determining the supply, demand, transport and sale of potatoes produced in Scotland. The earlier part of the report deals with the circumstances governing the production and disposal of the crop, the geographical limits of the area of production for sale, the number of growers, the sizes of their respective businesses, the aggregate volume of supplies available type by type, district by district, and season by season, and the nature, strength and fluctuations in demand. The various means by which the risks and processes of marketing are undertaken are then brought under review before turning to an examination of the price phenomena of the trade. Attention is given in the final chapter to the conditions which must be fulfilled if the effects of fluctuating supplies are to be mitigated by common action and the difficulties of the problem are considered with a view to defining the limits of practicable achievement.

A report on the marketing of live stock in Scotland has been published (3). This publication deals with the numbers and distribution of cattle, sheep and pigs in Scotland, and with the factors which influence both supply and demand and thus control price. An attempt has been made to analyse the Scottish and English demand for fat and store stock of Scottish production as well as the Scottish demand for Irish and Canadian cattle. Special attention has been devoted to the export of dead meat and fat and store stock to English markets. The sources of supply from which these

various forms of demand are satisfied have been traced. The movements of live stock by rail and sea are described, and the present organisation for sale, which is mainly centred in auction marts, is set forth. A final chapter relates to the movements of prices, which are discussed at some length in view of the fluctuations of recent years. A special feature of the report is the full statistical illustration given throughout.

A report on the marketing of grain and grass seed in Scotland has been published (4). The nature of the subject and the amount of material available have not admitted of the full statistical treatment that was applied in the two previous reports on the marketing of potatoes and live stock, but the first chapter presents a comprehensive statement on the supply situation in Scotland in its various aspects, together with an examination of the volume and importance of imported supplies. The second chapter is devoted to the various kinds of demand, the third embraces the organisation of the trade, threshing, dressing and sampling, assembly and distribution, storage and movement, while the final chapter is concerned with the all-important problem of prices.

Titles of papers issued during the year.

1. Department of Agriculture for Scotland. Third report on the profitableness of farming in Scotland, 1930-31. H.M.S.O., 1933.
2. ————: Report on the marketing of potatoes in Scotland. H.M.S.O., 1933.
3. ————: Report on the marketing of live stock in Scotland. H.M.S.O., 1933.
4. ————: Report on the marketing of grain and grass seed in Scotland. H.M.S.O., 1933.
5. King, J. S.: The place of economics in agricultural education. *Agric. Prog.*, **10**, 73, 1933.
6. Senior, W.H.: Salesmanship in agriculture. *J. Incorp. Sales Managers' Assoc.*, June, 1933.
7. McClymont, R. G.: Enterprise studies—Live stock. *Agric. Prog.*, **10**, 26, 1933.

J

PRESERVATION AND TRANSPORT

42. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

Food Investigation.

During the year, investigations have been in progress on the following topics. A full account of the work will be found in the Report of the Food Investigation Board for the Year 1933.*

(1) Low Temperature Research Station.

(In conjunction with the University of Cambridge.)

Meat.—Physiology of muscle protein (5); evaporation of water from tissues; freezing of tissues; changes in the muscle pigments; changes in fats during storage (14); bacteriology (8, 9, 10, 11); storage of meats in carbon dioxide (4), (23); storage of meat in small refrigerators.

Fruit and Vegetables.—Influence of the composition of the atmosphere upon the incidence of the climacteric in apples; cause of low-temperature breakdown in apples; effects of ethyl alcohol upon the respiratory metabolism of apples; substrate of respiration in the potato (2); effect of ethylene on the respiration and sugar-content of potatoes; acetaldehyde and ethyl alcohol contents of apples during storage; changes in the nitrogen-content of apples during growth; injurious effects of atmospheres of pure oxygen upon apples and pears at low temperatures; frozen fruits and vegetables (3); effect on the vitamin-C content of apples of storage in the frozen state in the presence and absence of molecular oxygen; sprouting in clamped potatoes; effect of freezing on the yield of seed potatoes; importance of small differences in temperature in the cold storage of apples.

Pork, Bacon and Hams.—Manufacture of Wiltshire bacon; penetration of salt during curing; gas-storage of bacon; water and fat content of pork muscle; theory of curing.

Biological Engineering.—Water-relations of tissues; metabolic constants of bananas; thermal properties of butter; atmospheric control and leakage; diffusion in fruits.

Canning.—Corrosion (15); changes in the pectic substances of fruits during storage; concentration of orange juice; vitamin C in canned apples.

* H.M. Stationery Office (Price 4s 0d. net).

Ditton Laboratory.

Fruit and Vegetables.—Gas-storage of apples (Monarch, Cox's Orange Pippin, Blenheim Orange, Worcester Pearmain); control of superficial scald of apples; effect of root-stock on the keeping quality of Bramley's Seedling apples.

Biological Engineering.—Distribution of temperature in a stack of fruit; transfer of heat and water in a wet cooler, lateral discharge from ducts; the plate cooler; eliminators.

Titles of papers issued during the year.

1. Adair, G. S.: The osmotic pressure of protein solutions. *J. Int. Soc. Leather Trades' Chemists*, **17**, 143, 1933.
2. Barker, J.: Analytic studies in plant respiration. IV and V. The relation of the respiration of potatoes to the concentration of sugars and to the accumulation of a depressant at low temperatures. I. The effect of temperature-history on the respiration/sugar relation. II. The form of the normal respiration/sugar relation and the mechanism of depression. *Proc. Roy. Soc.*, **112**, 316, 1933 B.
3. Barker, J., and Morris, T.: The preservation of fruit and vegetables by freezing. *Food Investigation Leaflet No.* 2, 1932.
4. Brooks, J.: The effect of carbon dioxide on the colour changes or bloom of lean meat. *J. Soc. Chem. Ind. Lond.*, **52**, 17T, 1933.
5. Finn, D. B.: Denaturation of proteins in muscle juice by freezing. *Proc. Roy. Soc.*, **111**, 396, 1932B.
6. Glennie, A. E.: Index to the literature of food investigation. *H.M. Stationery Off., Lond.*, **4**, 2, September, 1932 and **5**, 1 and 2, March and September, 1933.
7. Griffiths, E., Vickery, J. R., and Holmes, N. E.: The freezing, storage and transport of New Zealand lamb. *Food Investigation Special Report No.* 41, 1932.
8. Haines, R. B.: The influence of the medium on the production of bacterial gelatinase. *Biochem. J.*, **26**, 323, 1932.
9. ————: The influence of carbon dioxide on the rate of multiplication of certain bacteria, as judged by viable counts. *J. Soc. Chem. Ind. Lond.*, **52**, 13T, 1933.
10. ————: Observations on the bacterial flora of some slaughterhouses. *J. Hyg. Camb.*, **33**, 165, 1933.
11. ————: The bacterial flora developing on stored lean meat, especially with regard to "slimy" meat. *Ibid.*, **33**, 175, 1933.
12. Hale, H. P.: The freezing-point of yolk and white of egg. With a note by Sir W. Hardy. *Proc. Roy. Soc.*, **112**, 473, 1933 B.
13. Kidd, F., and West, C.: The cold-storage of English plums. *Food Investigation Leaflet No.* 1, 1932.
14. Lea, C. H.: Chemical changes in the fat of frozen and chilled meat. IV. The protective influence of carbon dioxide on the fat of beef stored at 0°C. V. The effect of smoking and the influence of atmospheric humidity on the keeping properties of bacon. *J. Soc. Chem. Ind. Lond.*, **52**, 9T and 57T, 1933.
15. Morris, T. N., and Bryan, J. M.: The influence of traces of a salt of tin in acid solution on the rate of corrosion of mild steel. *Trans. Faraday Soc.*, **29**, 395, 1933.
16. Roche, J., Roche, A., Adair, G. S., and Adair, M. E.: The osmotic pressure of globin. *Biochem. J.*, **26**, 1811, 1932.
17. Smith, A. J. M.: Refrigerated holds and the carriage of foodstuffs. *Trans. Inst. Eng. Shipb. Scotland*, **76**, 531, 1933.

18. Smith, W. H.: Evaporation of water from apples in relation to temperature and atmospheric humidity. *Ann. Appl. Biol.*, **20**, 220, 1933.
19. Taylor, G. L., Adair, G. S., and Adair, M. E.: The estimation of proteins by the precipitation reaction. *J. Hyg. Camb.*, **32**, 340, 1932.
20. Tomkins, R. G.: The action of certain volatile substances and gases on the growth of mould fungi. *Proc. Roy. Soc.*, **111**, 210, 1932 B.
21. ————: Measuring germination. *Trans. Brit. Mycol. Soc.*, **17**, 147, 1932.
22. ————: Measuring growth. The petri-dish method. *Ibid.*, **17**, 150, 1932.
23. ————: The inhibition of the growth of meat-attacking fungi by carbon dioxide. *J. Soc. Chem. Ind. Lond.*, **51**, 261T, 1932.
24. Vickery, J. R.: The yellowing of the abdominal fat of frozen rabbits. *Food Investigation Special Report No.* 42, 1932.

43. FRUIT AND VEGETABLE PRESERVATION RESEARCH STATION, CAMPDEN, BRISTOL UNIVERSITY.

Fruit Canning.

Hydrogen swells and perforations.—The investigation of the problem of corrosion of fruit cans has been continued, and an increased number of experiments have been carried out on this subject during the year.

The rate at which hydrogen swells are likely to develop has been studied. In these tests very severe temperature conditions are employed, the cans being stored continuously at 95° F.; at this temperature the losses are very great with most fruits after five or six months storage.

Experiments were carried out in collaboration with the Director of Victualling of the Admiralty, and cans packed under controlled conditions at Campden were stored and examined regularly at H.M. Victualling Yards at Malta and Hong Kong. Similar cans were also sent to Nigeria.

Comparison with other control tests showed that the fruit packed in these cans was about normal as regards the rate of corrosion when stored at 95° F. in the Campden Tropical Room.

Figures obtained show that the Campden storage conditions are decidedly more severe than those ruling in the tropical temperatures of the Hong Kong depot or in the sub-tropical conditions at Malta. The results confirm the fact that after several months' storage certain canned fruits, such as plums, are likely to develop an appreciable percentage of hydrogen swells.

Appearance and flavour of canned fruits stored under tropical conditions.—Discoloration in canned fruit stored at high temperature is very marked in red and purple fruits. The change in colour is due to the exposure of metal, and can only be overcome by improvement of the lacquer surface of the interior of the cans. In this connection thirty-eight different lacquers or variations in lacquer have been tested during the year.

In addition to the alteration in colour due to the action of the fruit acid on the metal, there appears to be a natural falling off in

the original bright colour of the fruit brought about by the effect of high temperature only, and this is particularly noticeable in the browning of gooseberries, yellow plums and greengages. The effect of high temperature alone is being studied in fruits packed in all-glass containers.

In connection with the storage tests at Hong Kong and Malta, samples of each fruit were opened monthly and reported upon for appearance and flavour. An examination of the Hong Kong reports shows that strawberries had a good colour up to ten months' storage, but the texture and flavour showed marked deterioration after nine months. Raspberries kept a good colour and flavour up to five months, but were becoming rather soft at this stage. Nine or ten months' storage caused the colour to turn to a faded bluish shade, and the berries were then extremely soft. Victoria plums retained their colour and flavour for seven months, but they were becoming slightly soft in texture. The Malta reports show that strawberries remained in good condition after eleven months' storage, and Victoria plums were also quite satisfactory except for slight softening in texture. Raspberries remained in good condition for five months after which the colour began to deteriorate, and after seven months the berries were becoming soft and the syrup cloudy. The fruit was in very poor condition after eleven months.

Heat-resistant mould.—Special attention has been given to a new species of mould which causes disintegration of canned fruits. In most cases the mould was visible as a small white disc of mycelium floating on the surface of the syrup. The causative organism was found to be a mould of a rather unusual type, since identified as a new species belonging to the genus *Byssochlamys*. It was named *Byssochlamys fulva*, and a description was published in a paper by Olliver and Smith in the Journal of Botany in July 1933.

The highly heat-resistant capacity of the spores of this fungus—the mature spores can survive cooking for thirty minutes at 87° to 88° C.—makes its destruction very difficult by the normal processes of sterilisation. The only safeguard is to prevent the infection entering the factory. At present the source of the mould is not known, but evidence points to the fact that certain areas are infected, and that the fungus may remain in strawberry plantations for a number of years. In a preliminary investigation during the past season fruit, plants, soil, manure and chip baskets have been examined from suspected plantations, and every possible source of infection has been explored. Cans of all the principal fruits have been inoculated with the spores of *Byssochlamys fulva*, and they have been processed for various periods to determine the heat-resistance of the mould under practical conditions. The investigation is being continued.

Solid pack apples.—An extensive series of experiments on this product have been carried out. Special attention has been given to the influence on the apple slices of soaking in brine, steaming,

blanching, and other processes affecting heat penetration during sterilisation.

Variety trials.—For the third successive season special attention has been given to the canning of cherries and cultivated blackberries. In addition twelve new varieties of plums and several new types of berries have been tested.

Exhaust process.—Continuing the work commenced last year, a further series of tests have been made on the effect of time and temperature of exhaust on the subsequent condition of canned fruits.

Size grading of fruits.—The relation between the transverse diameter and the weight of the larger fruits, and the distribution of the various sizes have again been studied. Cans have been packed showing the full spread of sizes for each grade of National Mark canned fruits.

Vegetables.

Variety trials.—Over one hundred and twenty varieties of vegetables have been grown in the Research Station garden, and full records of methods of cultivation, yields, etc., have been kept. In addition varieties of peas, broad beans, asparagus, carrots, tomatoes, beetroots, and new potatoes were received from other sources. About two hundred and twenty canning trials have been carried out.

Maturing of green peas.—The changes in the composition of peas during the ripening period have been studied. Six of the principal varieties used for canning have been grown in the Research Station garden, and samples of each have been taken for over a period of about one week before and after the stage of ripeness considered best for canning purposes. Changes in moisture, ash and calcium content have been determined, and observations made on the yield of different grades. Samples have been suitably preserved for future analyses during the winter months, when the changes in the carbohydrates will be determined, with particular reference to the conversion of sugar to starch.

Vegetable purées.—Experiments on the production of these products have been carried out, and purées of carrots, beetroots, and turnips have been prepared.

Thermophilic infection.—The study of spoilage of vegetables through the action of heat-resistant bacteria has been continued. Extensive tests were made in three factories during the canning season to trace the chief sources of infection.

Dairy Products.

Canned cream.—An interesting case of bitterness in canned cream has been investigated and the bitter flavour was found to be due to the presence of a bacillus, the spores of which had survived sterilisation. The organism was isolated in pure culture;

inoculations were made into sterile cream, and after a period of incubation the characteristic bitterness developed. Cans filled with cream which had been inoculated with the spores were heated at the same temperature and for the same length of time as commonly used in commercial practice. The organisms survived and the cream developed the bitter flavour. A slight increase in the time and temperature of processing rendered the canned cream sterile.

Marine Products.

Canning of cockles.—Experiments on the canning of cockles have been completed. It is possible that canned cockles will be produced on a commercial scale in the near future.

Experiments are also being carried out on the canning of mussels, oysters, and laverbread (seaweed).

Internal Rusting of Cans.

Methods for the prevention of the rust stains which are produced on the inner surface of cans under certain conditions have been worked out and the conditions governing the rusting are being more fully studied, the composition of the gas inside the cans receiving special attention.

Titles of papers issued during the year.

1. Adam, W. B.: Factors affecting the pressure in cans. Paper: Canners' Conf. Imp. Fruit Show, Birmingham, October, 1932. *Food Manufacture*, November, 1932.
2. ————: Grading of fruits for canning. *Ann. Rep. Fruit and Veg. Preservation Res. Sta., Campden, Glos.*, 33, 1931-32.
3. Adam, W. B., and Stanworth, J.: Investigation of the pressures produced in cans during sterilisation. *Ibid.*, 44, 1931-32.
4. Hirst, F.: Problems affecting the export of canned fruits and vegetables to hot climates. Paper: Canners' Conf. Imp. Fruit Show, Birmingham, October, 1932. *Food Manufacture*, November, 1932.
5. ————: Canning of fruit and vegetables: What the canner wants. Paper: Conf. on "Recent developments in market gardening". Rothamsted Exp. Sta., Harpenden. *Rothamsted Conferences*: XV, December, 1932.
6. ————: Cultivation of vegetables for canning. Paper read at the Midland Agricultural College, Sutton Bonington. *Food*, April and May, 1933.
7. ————: Preliminary observations on flat sour spoilage in canned peas. *Ann. Rep. Fruit and Veg. Preservation Res. Sta., Campden, Glos.*, 65, 1931-32.
8. Hirst, F., and Adam, W. B.: Effect of high temperature on the storage of canned fruits. *Second Supp. Canners' Bull. No.* 1, *Res. Sta., Campden, Glos.*, June, 1933.
9. ————: The canning of solid pack apples. *Misc. Publ., No.* 2, *Res. Sta., Campden, Glos.*, 1933.
10. ————: Varieties of fruits: Canning trials. *Ann. Rep. Fruit and Veg. Preservation Res. Sta., Campden, Glos.*, 17, 1931-32.
11. ————: Varieties of vegetables: Canning trials. *Ibid.* 24, 1931-32.
12. ————: Canning of chilled and frozen fruits. *Ibid.* 69, 1931-32.
13. Horner, G.: Factors influencing the hardness of dried peas. *Ibid.* 56, 1931-32.

K

AGRICULTURAL ENGINEERING

44. AGRICULTURAL ENGINEERING RESEARCH INSTITUTE, OXFORD UNIVERSITY.

Tractors.—The first portion of the work on tractor wheel adhesion is nearing completion and the results obtained will shortly be made available.

An event of some importance to farming practice has been the appearance on the market this year of pneumatic wheels for farm carts and tractors. The Institute has carried out very full experiments on both these interesting items of equipment, and many tests have been made at the Field Station and elsewhere on their performance.

Seed drills.—Further work has been carried on during the past year in co-operation with the Norfolk Experimental Station on spacing drills, of which three distinct types have been studied with satisfactory results.

Haymaking.—A short paper on haymaking machinery has been published during the year (9). Work has been continued with the Combine Hay Baler purchased last season, and results of importance have been secured on the baling of high moisture content hay, amplifying and confirming the work of last season.

The Institute has constructed a tractor operated power stacker, which will be tried out next season. The question of equipment for the new " short grass " system is being investigated, and the Institute is hoping to carry out experiments with this next season.

Harvesting.—The exceptional harvest of 1933 gave full scope to the combine harvester; 48 machines were at work in 1933 as against 25 in 1932, 10 in 1931 and 4 in 1930. A new small type has now been produced in the U.S.A., embodying several features of great interest which should particularly suit it for the conditions of this country.

A number of alternatives to the Combine Harvester have been tried out with some success. One of these involved the design of a special low loading trailer on pneumatic tyres by the Institute, which proved very successful in practice.

Root crop cultivation.—The experiments in co-operation with the Norfolk Agricultural Station have now been completed, and the equipment will be transferred to the Field Station. These experiments, which were moderately successful, showed that mechanisation of a root crop was feasible if a good " plant " could

be obtained in the first instance. This work is still in its infancy and will require to be spread over several years, and will necessitate the construction and purchase of a number of implements. There are, more than ever, strong grounds for believing that very important economies can be secured.

Spraying.—Work on the control of annual weeds by sulphuric acid spraying has been continued. Conditions at the time of spraying in 1933 were completely different from last season, and results of great interest have been secured, which are now being worked out. A paper summarising all the available information was published in the spring (2). Certain modifications in the method have been suggested which have had considerable influence on its efficacy, and the Institute is anxious to construct an experimental sprayer embodying further innovations of some importance.

The Institute is co-operating with the East Malling Research Station on problems of fruit spraying equipment.

Mole draining.—A number of experimental mole drains have been laid down near Oxford, and special equipment has been constructed to make measurements of their performance. Part of this has already been installed, and the remainder will be set to work before the winter.

Electricity in agriculture.—This summer marked the completion of the National " Grid ". The position of electricity in agriculture is, however, still far from satisfactory in the majority of farming districts, partly owing to the high charges for connections and for current, and partly to the absence of information on available equipment and methods. It has been decided to publish a number of papers dealing with this, and to follow a policy of extending existing applications rather than the investigation of new and untried developments. A paper on the use of electricity for soil heating has been published (5), and one on the use of electricity for pumping is in preparation, to be followed by a further note on farm wiring.

Laboratory work.—Work is being continued on the effect of drying temperatures on the germination of grain, with particular reference to the vexed problem of malting barley, on which already data of some importance have been collected.

The simple method of moisture testing referred to in the last report has been published (4). This has found an unexpected sphere of usefulness in the measurement of the moisture content of hay and herbage, which has hitherto been a lengthy operation, and is being extended to many other materials. Most of the outstanding difficulties in the application of this method to soils, first suggested by Boyoucos, have now been overcome.

Survey of mechanised farms.—Two more mechanised farms have been included in this survey during the year, making a total of 14. Ten others are being considered. Visits to the farms in the survey

have been restricted, but it has still been found possible to secure much information of considerable importance on a number of problems, and a paper on the subject is in preparation.

Testing.—The number of machines tested under the Ministry's scheme during the year was two. Two machines were tested on behalf of the Royal Agricultural Society as entrants for the Silver Medal.

Titles of papers issued during the year.

1. Abstracts of current literature, 6-8, 1932 and 1933.
2. MacDowall, R. K.: Weed destruction by sulphuric acid spraying, March, 1933.
3. Brown, C. A. Cameron: Windmills for the generation of electricity, May, 1933.
4. Cashmore, W. H.: A rapid method of measuring the moisture content of wheat. July, 1933.
5. Brown, C. A. Cameron: The use of electric heating cables for hot-beds. July, 1933.
6. Newman, J. E.: The combine harvester in 1932.
7. Brown, C. A. Cameron: Soil heating by electricity. Paper: Sessional Meeting of the Institution of Heating and Ventilating Engineers, Jan. 4, 1933.
8. Denham, H. J.: Electricity in mechanised farming. *Scot. J. Agric.*, April, 1933.
9. Cashmore, W. H., and Newman, J. E.: Development of haymaking machinery. *Emp. J. Exp. Agric.*, April, 1933.
10. Wright, S. J.: Tractor costs analysed. *Farmer and Stockbreeder*, May 8, 1933.
11. ————: Farm implements and machinery. Farmer's Guide to Agricultural Research in 1931. *Roy. Agric. Soc. of England.*
12. Newman, J. E.: Recent developments in mechanised farming. *Estate Mag.*, Jan., 1933.
13. ————: More uses for cheap power. *Farmer and Stockbreeder*, May 8, 1933.
14. ————: Getting on top of the work. *Ibid.*, Aug. 21, 1933.
15. ————: Can the engineer cheapen wheat? *Countryman*, July, 1933.
16. ————: The machine and the farmer. *Saturday Rev.*, July 1, 1933.

II

LOCAL INVESTIGATIONS AT ADVISORY CENTRES

L

CHEMISTRY

45. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES.

The result of the investigation dealing with the comparison of the nitrogen and mineral content of the pasture, hay and aftermath of grasses grown in a mixture, pure plots and pure drills has been published (1).

The following problems are at present under investigation :—(*a*) A study of the principal chemical changes taking place on the conversion of grass into ensilage; (*b*) a study of the variation in total, digestible, true, amide and ammoniacal nitrogen of pasture grass cut at monthly intervals during the growing season; (*c*) the effect on their mineral content of growing lowland grasses at varying altitudes; (*d*) the composition of the grain and straw of ten varieties of oats with the object of ascertaining their suitability to our conditions; and (*e*) a study of the chemical composition of the by-products obtained in the milling of the above varieties of oats.

The farmers of this area are realising that the making of silage offers one way of preventing the loss of valuable foodstuffs. In 1932 a demonstration in silage making was carried out at the College Farm, Nantcellan, when two types of silage were made, one by the ordinary " Pit " method and the other by the " A.I.V." process. The result of the chemical examination of these two types of silage is included in the report. Both types of silage were fed to cattle and it is intended to publish the data at a future date when the results of more extensive trials which are at present in progress are completed.

Title of paper issued during the year.

1. Fagan, T. W., and Milton, W. E. J.: A comparison of the nitrogen and mineral content of the pasture, hay and aftermath of four species of grasses grown in a mixture, pure plots and pure drills. *Welsh J. Agric.* **9**, 1933.

46. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

Further progress has been made with the soil survey of Wales. The final stages in the mapping of Anglesey proved unexpectedly difficult and have formed the greater part of the field operations of the surveyors. In addition, progress has been made in the Conway Valley district of Caernarvonshire. Detailed surveys of a semi-advisory character were made in the Sealand district of Flintshire, and in the Bangor district. The exceptional drought caused the complete suspension of field work during part of the summer.

Investigations are being carried out on the composition of the clay fraction with a view to its use in defining soil series. The results are proving of considerable interest and give the possibility of more precise definition of soils. The character of the clay fraction has probably a marked significance in the relationships of soils to plant growth and in their responses to manurial treatment.

Problems of the reaction of unsaturated soils with calcium carbonate have been investigated, whilst some preliminary work on vanadium in North Welsh soils has been begun.

Titles of papers issued during the year.

1. Williams, R.: The determination of exchangeable bases in carbonate soils. *J. Agric. Sci.*, **22**, 838-844, 1932.
2. ————: The contribution of clay and organic matter to the base exchange capacity of soils. *Ibid.*, **22**, 845-851, 1932.
3. Robinson, G. W., and Richardson, M.: The dispersion of soils in mechanical analysis. *Imp. Bureau Soil Sci., Tech. Com.*, 26, 1-31, 1933.
4. Walters, W. G. D.: A note on a preliminary investigation into the mineral content of some typical N. Welsh pastures. *Welsh J. Agric.*, **9**, 109, 1933.

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47. BRISTOL UNIVERSITY.

Longleat grazing experiments.—The following conclusions may be drawn from these experiments which had been in progress since 1927 and were concluded during 1932:—

(*a*) The division of 34 acres of poor pasture into two equal fields was followed by a permanent increase in the stock-carrying capacity and the nutritive value of the herbage.

(*b*) The sub-division of 27 acres into small paddocks of $4\frac{1}{2}$ acres and the rotational intensive grazing of these by cattle was followed by:

(i) No significant increase in the nutritive value.

(ii) No increase in stock-carrying capacity.

(iii) Subsequent deterioration of the pasture after maximum productivity had been obtained in the second year.

(*c*) In periods of drought intensive grazing was followed by a fall in productivity, recovery was slow and unassisted by nitrogenous fertilisers.

(*d*) Intensive grazing late in the season was followed by delayed development and low production in the following spring.

(*e*) Complete manuring produced a significant increase in quality of the herbage and the stock-carrying capacity of the pasture.

(*f*) The influence of a good season upon the quality of the herbage and productivity was comparable with that obtained by complete manuring.

(*g*) Soil acidity and phosphate deficiency were limiting factors.

The seasonal variation in the nutritive value of 2nd grade natural pastures in the West of England.—Examination of a large number of herbage samples collected during the past five years has shown that :—

(*a*) Natural cow pastures are characterised by a low protein content in the month of June. This is reflected in the milk yields which invariably fall off towards the end of June and beginning of July.

(*b*) Winter herbage has a relatively high nutritive value.

(*c*) Throughout most of the year the lime and phosphoric acid contents of the herbage are slightly below those for good grazing pastures.

Wiltshire pasture experiments.—Three plots were established on typical Wiltshire Down herbage in 1929. One plot was intensively manured with nitrogen and cut at three-weekly intervals, a second plot was cut but not manured, and a third plot was cut for hay once a year. Results showed a very definite gain in yields from the manured plot, the percentage of gain for each year being as follows :—1929—238 per cent., 1930—424 per cent., 1931—154 per cent. and 1932—96 per cent. Of the unmanured plots, that cut at three-weekly intervals showed an increasing advantage in yield over that cut annually, the yield of the former in 1932 being roughly 50 per cent. higher than the latter.

The eradication of weeds of arable land.—The results of these experiments indicate that sodium chlorate applied in the autumn to weedy arable land at the rate of 2 cwt. per acre and used in conjunction with the usual cultural operations will bring about the eradication of couch grass, creeping bent, crow-foot and other shallow-rooted weeds. Creeping thistles are reduced, but field and black bindweed, docks and other fleshy deep-rooted plants are unaffected.

Basic slag as a phosphatic manure for sugar beet.—Experiments conducted in Hereford, Gloucester, Wiltshire and Worcester on

acid sandy soils, have demonstrated the great value of this fertiliser in the growing of sugar beet.

The problems at present under investigation are :—(*a*) The effect of mole draining on the mechanical and chemical composition of the soil; (*b*) the Teart lands of Somerset; (*c*) the effect of simple manurial systems in the nutritive value of herbage; (*d*) the nutritive value of winter herbage; (*e*) comparison of the yield and nutritive value of fodder obtained by the practices of Grazing, Haymaking, and Silage making; and (*f*) the effect of poultry on the chemical composition of the soil and herbage.

Titles of papers issued during the year.

1. Ling, A. W.: The management and manuring of grassland. *Worcs. Chron.* **1**, No. 1, Nov., 1932.
2. ————: Improvement of grassland for dairy stock. *J. Brit. Dairy Farmers' Assoc.*, **45**, 1933.
3. ————: The liming of Acid soils in Gloucestershire. *Gloucs. Farmer*, **1**, No. 1, Jan., 1933.
4. ————: Sugar beet in Worcestershire. *Worcs. Chron.*, **1**, No. 2, Feb., 1933.
5. ————: Sugar beet in Herefordshire. *Hereford. J.*, **1**, No. 1, March, 1933.
6. ————: Grass silage. *Worcs. Chron.*, **1**, No. 3, May, 1933.
7. ————: Autumn feeding after the drought. *Farmer and Stockbreeder*, August 28th, 1933.
8. Ling, A. W., and Haggard, A.: The eradication of weeds of arable land by sodium chlorate. *J. Min. Agric.*, **40**, 3, June, 1933.

48. CAMBRIDGE UNIVERSITY.

Liming.—The experiments referred to in previous reports have been continued during this season. Yield data have again been obtained where possible, and the results are proving of value not only in stimulating interest in liming in the areas which, as reported elsewhere, are now beginning to suffer from lime deficiency, but also in providing data of the greatest assistance in advisory work. A further centre has been established this season in conjunction with the Director of Agricultural Education for Norfolk, on a soil showing only slight acidity. It is hoped, by the use of modern methods of experimentation, to ascertain with greater certainty, the point at which liming becomes a definite paying proposition on such soils.

Manuring.

(a) *Phosphatic manures.*—(i) Experiments to test the value of the cheaper phosphatic fertilisers, and different schemes of manuring, on black peaty fen soils are still in progress.

(ii) Experiments on the use of phosphate for sugar beet in two districts where the soil was suspected of being low in phosphate have given unexpectedly striking results. In both cases, the omission of phosphate led to almost complete failure of the crop.

(b) *Potash and salt.*—Experiments on the use of these for the sugar beet crop were carried out at two centres, one being on a very light fen peat which had been unmanured for some years and the other on a light soil overlying chalk. The light fen gave an extraordinary response to potash—the omission of all potash causing complete crop failure on many plots. The few beets which survived on the control plots gave an average yield of washed roots of only 3·4 tons per acre and a sugar content of only 11·82 per cent. as compared with 13 tons per acre and 15·63 per cent. in the case of beets from the full potash plots. There is a considerable area of this type of fen in the district and the experiment was watched with much interest by local growers of sugar beet, many of whom have little experience in the use of fertilisers on this light peat. No significant response was obtained from dressings of salt either alone or in conjunction with potash at this centre.

On the light soil (over chalk) on the other hand, response to salt was quite definite.

(c) *Chicory.*—Experiments on the manuring and spacing of this crop are being continued again this year on three soil types in Huntingdon and Bedford, but the results are not yet available. The chicory crop is becoming of considerable importance to smallholders in the district and in many respects seems better suited to this class of holding than to the larger farms.

(d) *Application of manures.*—The advisory chemist has again co-operated in experiments on manuring for early potatoes on light Greensand soils in Bedford and Cambridge. As a result of three years' experiments it appears that the requirements of the early potato crop for potash on these soils are very small. Further, varying the time of application of the potash, even to the extent of applying it in the previous autumn, does not appear to affect this result.

The experiments on the methods of applying manures for cereals and sugar beet (broadcast *v.* drilling with seed) have been continued. The results have been satisfactory and it is hoped that the experiments will be extended next season.

(e) *Dried poultry manure.*—Experiments on the use of this material for market garden crops were carried out. On brussels sprouts and potatoes in the year of application it proved as good as equivalent quantities of other organic manures or of artificial nitrogenous manures. A further experiment is in progress to compare the values of wet and dried poultry manure with equivalent artificial nitrogen for the carrot crop.

Titles of papers issued during the year.

1. Hanley, F.: Poultry manure. *Agric. Prog.*, **10**, 99, 1933.
2. Hanley, F., and Sayce, R.: The production of kiln-dried poultry manure. *J. Min. Agric.* **39**, 656, 1932.

49. HARPER ADAMS AGRICULTURAL COLLEGE.

Soil survey.—The mapping and classification of the soils of North Shropshire have been continued. While the usual rate of progress is about 30,000 acres per annum, the work of this season has fallen 8,000 acres below this figure, the main cause being due to the extremely hard condition of the soil resulting from drought. It is hoped to present a report on the soils of this area shortly. The laboratory work in connection with the survey is proceeding satisfactorily. After the conclusion of the work on the area at present under survey, it is proposed to work on an area extending from the north to the south of the county.

Soils acidity.—The liming experiment (Class A) has been conducted during 1933 on the lines of the previous seasons. Red clover was grown and striking results again obtained.

Grassland experiments.—The following experiments on grassland have been concluded during the past summer :—

(a) *The effect of phosphates on yield and composition of hay.*—This experiment (5 by 5 Latin square), laid down at the request of Rothamsted Experimental Station and the Basic Slag Committee, was carried on over four seasons. Although the results, measured in terms of yield, were marked in one year only, those in composition (P_2O_5 particularly) were more definitely instructive. Increases in the P_2O_5 content of the dry matter resulted from all treatments, viz., superphosphate, mineral phosphate, high grade slag, and low grade slag.

(b) *Manuring for hay on peat soils* 1931-1933.—This experiment, now completed, was laid down with a view to ascertaining the manurial treatment required on a large patch of peat, covering some thousands of acres in North Shropshire. A section which had received no manurial treatment was chosen and dressed with superphosphate, mineral phosphate and muriate of potash, singly and in suitable combinations. Yields have been measured in terms of dry matter per acre. Owing to the heavy rains at harvest time in 1932, it was impossible to obtain results which could be regarded as satisfactory and these have consequently been discarded.

Results for the first year (1931) were striking both with potash and phosphates singly and when applied together, but the results for 1933 were not quite so marked. The combined results for both years show that the effect of treatment is significant.

Animal drinking supplies.—Included in the twenty-four samples of water analysed during the year were a number presumed to be causing ill health (and in some cases death) to animals. In one case where the water was pumped from a coal pit to which animals had access, the chloride content was so high (136 parts per 100,000) as to cause emaciation. The total solids on the same sample were 264 parts per 100,000.

Manganese deficiency causing " grey speck " in oats.—Oats were again grown on the experimental land where this disease had occurred in Warwickshire. No signs of the previous season's application of $MnSO_4$ were visible in the crop and the attack was severe. It is intended again to plant oats and to measure the yields resulting from definite pre-treatments.

Title of paper issued during the year.

Davies, W. M.: The use of lime in agriculture. *J. Roy. Agric. Soc. England*, **93**, 1932.

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50. LEEDS UNIVERSITY.

Ammonium bicarbonate.—Field experiments on the value of ammonium bicarbonate as a fertiliser were continued during the year at the University Farm. Those on swedes were unfortunately ruined by the drought of the summer, but results of value were obtained on the potato crop. These showed that when ammonium bicarbonate was used as a fertiliser the yield per acre of potatoes in 1933 was 10,640 lb., when sulphate of ammonia was used it was 10,600 lb., whereas when no nitrogen was supplied the yield was only 6,300 lb. Comparable figures for 1932 are 18,640 lb., 24,480 lb., and 14,560 lb.

Similar experiments were carried out with wheat with the following results:—Ammonium bicarbonate—13,860 lb., sulphate of ammonia—13,600 lb., and no nitrogen—12,960 lb. These figures represent the total produce per acre.

Small scale field experiments were also conducted in order to study the effect of ammonium bicarbonate on the reaction of the soil, and the rate at which nitrification proceeds. A marked initial rise in pH is followed by a gradual fall as nitrification progresses. It is hoped to continue these experiments next year.

Gas by-products.—Pot and field experiments have been started with two other by-products of the gas industry—concentrated gas liquor containing 8·5 per cent. nitrogen, and the salts crystallised from the liquor, containing 19 per cent. nitrogen. The experiments so far carried out have shown that the concentrated liquor has little toxic effect, and the salts, none.

Basic slag.—The experiment of phosphatic manuring of meadow hay (for the Permanent Committee on Basic Slag) was continued this year. Although the yield of hay was considerably lower than in previous years, the differences in yield from the various treatments were as striking as before, high soluble slag, for example, giving a 50 per cent. increase in yield over the " Untreated ".

Soil survey.—A start has been made on the soil survey of the Nidderdale, which shows a very interesting variation in types of farming.

51. MANCHESTER UNIVERSITY.

Liming experiment.—A quantitative liming experiment to be continued throughout the four course rotation has been laid down on a farm in Cheshire. Owing to the abnormally dry season the results this year are probably exceptional, the average yield of swedes from the 25 plots of the 5 × 5 Latin Square being 21 tons 7 cwt. while no significant response was obtained from any of the lime treatments.

Grey speck disease in oats.—In co-operation with the organiser for the district an experiment was carried out on the use of dressings of manganese sulphate and basic slag. A satisfactory degree of control of the disease was obtained from dressings of 56 and 112 lb. per acre manganese sulphate and from 5 and 10 cwt. per acre basic slag. It is hoped to continue this work next year to test the effect of smaller dressings of manganese sulphate mixed with the seed in the drill.

Manuring of glasshouse lettuce.—Twelve fertiliser treatments were used in an experiment in a glasshouse where the normal cropping is tomatoes followed by one or two lettuce crops. Apart from damage to the seedling plants on the plots receiving sulphate of ammonia no definite response was obtained from any fertiliser treatment, the residual fertilisers being sufficient to produce a normal crop. Plant ash analyses of samples from the plots showed the very high potash content of this crop.

Wool shoddy manure.—In co-operation with the Horticultural Instructor experiments were carried out at three centres to test the value of wool shoddy supplemented with artificials compared with F.Y.M. under market garden conditions. Considering the three experiments together the yields as percentages of the general mean were F.Y.M. 106·4, best shoddy manure 92·5, short shoddy manure 101·2. The mean yield of potatoes over the three experiments was 11 tons 5 cwt. per acre. It is intended to continue and extend these experiments next year.

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52. MIDLAND AGRICULTURAL COLLEGE.

Molassed beet pulp (taint in milk) enquiry.—This investigation, interim reports on which have been issued from time to time, has been continued for a fourth season. As previously noted, this problem is being studied also at the National Institute for Research in Dairying, Shinfield. Although considerable progress has been made, the solution of this problem is still far from complete.

A satisfactory method of estimating the tertiary bases in milk and in beet products having been worked out, betaine and trimethylamine were fed to cows in a normal ration, and the milk

examined. Although 80 grams of betaine and 30 grams of trimethylamine respectively were fed at one meal to a single cow, no marked effect on the milk was noticeable, in fact only traces of trimethylamine were found in the milk produced during these experiments. A search was therefore made for a possible intermediate product which might prove to be the causative agent of the taint. Since betaine is submitted to fairly high temperatures in the drying of the pulp, a study has been commenced of the products resulting from the heating of betaine. Substances possessing a distinct "crab" odour have been detected but their constitution is at present unknown.

Control of mites in Stilton cheese dairies.—Further work on the use of ammonia gas for the destruction of cheese mites has been carried on during the past season. Excellent control has now been obtained (over 90 per cent. kills) by the use of cylinder ammonia gas at a concentration of 1 : 25. A report on this investigation is in course of preparation.

Composition of milk.—Through the courtesy of United Dairies Ltd. an examination has been made of the analytical records relating to the bulk milk passing through depots in the midland area during the period 1923-31. Average composition of the milk of various districts has been correlated with month of year, climatic conditions and management. A report has been published (1).

Owing to the paucity of information regarding the solids-not-fat content of Friesian milk, systematic recording of the composition of the bulk milk of several pure bred herds has been commenced.

Liming experiments.—In the spring of 1933 a large scale experiment consisting of 54 plots in six randomised blocks was laid down on the Bunter pebble beds in Notts. to ascertain the effect of lime with and without potash. The yields from this year's crop—sugar beet—have shown significant responses to both lime and potash.

Composition and use of sewage sludge.—The disposal of ordinary sewage sludge from the works of small towns is a problem of local importance. Information regarding the composition and use of this material, mainly for allotment and market garden purposes, is being collected.

Effect of alfalfa meal on the fat content of milk.—An experiment was carried out last winter to ascertain the validity of the claim which has been put forward in certain quarters that alfalfa meal fed to milch cows will increase the fat content of the milk produced and also increase the colour of the butterfat. The results obtained did not confirm either of these statements.

Titles of papers issued during the year.

1. Cranfield, H. T., and Baker, A. G.: Variation in the composition of milk in certain districts of England during the years 1923-31. *J. Dairy Res.*, **4**, 2, 1933.

2. Cranfield, H. T., and Murray, J. G.: Investigation into the damage caused to greenhouse crops by minute quantities of escaping coal gas. *Lindsey (Lincs.) C.C. Hort. Bull.*, 1933.

3. Cranfield, H. T., and Blood, J. W.: The purchase of milk on a quality basis, *Midland Coll. Bull.*, 28, 1933.

4. Cranfield, H. T.: A dairy farmer's problem. *Derbyshire Farmer*, **12**, 11, 1932.

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53. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

The investigation on the yield and composition of hay from certain of the Palace Leas plots at Cockle Park has now been completed, and it is anticipated that an account of it will be published shortly. In addition to the analytical examination of samples obtained during 1932, all available information as to the yield and composition of hay from these plots has been summarised. The use of basic slag, either alone or in conjunction with other artificial fertilisers, was shown to constitute the most effective treatment for the production of high quality hay. Manurial dressings from which the phosphatic component was omitted had a depressing effect. While the results of feeding trials are not wholly in agreement with those of analysis, they confirm the effectiveness of phosphatics.

The annual application of 8 tons of dung per acre has produced heavier yields than any other of the treatments investigated. Dressings which included basic slag were next in effectiveness. Muriate of potash, used alone, was the only treatment which depressed yield below that of the control plot. When the relative merits of the manurial treatments were assessed on the basis of total weights of digestible protein, lime and phosphoric acid produced per acre, the use of basic slag together with sulphate of ammonia and muriate of potash, or with either of the latter singly, has given the best results.

Investigations in progress include the following :—

(*a*) The yield and composition of pasture grass from intensively and non-intensively treated areas on Roundabouts Field at Cockle Park. (An extension of the preliminary investigation carried out in 1932.)

(*b*) The composition of winter grass; Two fields specially laid up for keep during the winters of 1932-33 and 1933-34 have been utilised for the purpose of this investigation.

(*c*) The composition of common heather (*Calluna vulgaris*) and other moorland plants of economic importance; an account of preliminary work on heather of varying age is now in the press.

Titles of papers issued during the year.

1. Thomas, B., and Elliott, F. J.: On the yields and composition of pasture grass from the Tree Field plots at Cockle Park. *J. Agric. Sci.*, **22**, 4, 736-754, Oct., 1932.
2. ————: A comparison of the yields and composition of pasture grass under intensive and non-intensive manurial treatment. *J. Soc. Chem. Ind.* **52**, 25, 182T-185T, June, 1933.
3. Thomas, B.: Some problems in agricultural chemistry. *Trans. Northumberland Agric. Discussion Soc.*, **3**, 51, 1932-33.
4. ————: Some emergency measures for the control of quality in milk. *Northumberland Milk Recording Soc. Official Handbook*, 1933.

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54. READING UNIVERSITY.

Low solids-not-fat in milk.—Investigations, lasting for a period of three years, have been concluded, and the data is in the course of preparation for publication. The milk constituents responsible for the solids-not-fat being below normal have been ascertained, but a practical solution of the problem has not been obtained.

Soil surveys.—Three surveys have been in progress. The work in the fruit area in North-West Berkshire has been completed, and the data is in course of preparation for publication. Preliminary work in the strawberry area in South Hampshire has been completed. A third small but intensive survey has been carried out in a forest area in Berkshire in conjunction with the Department of Botany.

Other investigations.—Experiments on the effect of cultural treatment on marrow-stem kale are being continued. The heaviest yields have been obtained from unsingled plots, but it is still doubtful if these plots also yield the highest weight of protein per acre.

Experiments on the manuring of seakale for forcing have been discontinued, owing to local difficulties of the grower in connection with suitable land and rotation of crops.

Work on the treatment on chlorotic conditions in carnations and chrysanthemums has been continued.

Preliminary work on the nutrition of bulbs has been commenced in conjunction with the Department of Horticulture, and work in conjunction with the Advisory Entomologist on bulb eelworm has been continued.

Title of paper issued during the year.

Nicholson, M. N.: Variations in the composition of milk. *N.F.U. Yr. Bk., Oxon. Bch.*, 1933.

55. SEALE HAYNE AGRICULTURAL COLLEGE.

Soil conditions associated with crop failures.—Investigational work during the past year has nearly all centred round the broad general problem of the correlation of soil conditions with the incidence of plant diseases of various kinds and application of practical remedial measures. This involves the determination of the nature of the adverse factors in soils in the first place, and in many instances observations during a somewhat long recuperative period. This applies especially to intensively cultivated crops, such as broccoli, violets, strawberries, etc., on land which has been completely unbalanced by years of wrong manurial treatment.

Strawberry patch disease.—The special scheme outlined in last year's report has been carried out and a large mass of suggestive data already obtained. In all cases of strawberry failure, whether due to insect virus or fungoid attack there is an abnormal concentration of nitrate nitrogen in the soil around the plant. The significance of this is not yet understood, but it has been found that on removal of such plants to sand media these unhealthy plants have a higher demand for nitrate nitrogen than healthy ones. This work is being continued and extended.

Potato eelworm.—A special survey of soils affected by the disease has been undertaken and promises to be very fruitful. Experiments at these centres were conducted with outstanding success in two instances. It is hoped to publish the particulars and results of one of them at least.

Manurial trials.—As a result of previous work, manurial trials have been initiated in a number of the intensively cultivated areas on a variety of crops such as violets, strawberries, etc.

Utilisation of apple pomace.—The use of apple pomace both as a fertilizer and as a feeding stuff is under investigation at a number of centres. The preliminary treatment to neutralize the acidity and to hasten decomposition for the former purpose has been started, and the necessary laboratory determination of the feeding value for the latter.

Soil survey.—Progress in mapping the South Devon area continues along the lines agreed to by the Soils Correlation Committee. No new soil types have been encountered.

Title of paper issued during the year.

Blenkinsop, A.: Soil conditions associated with crop failures in Devon and Cornwall. *J. Min. Agric.*, **40**, 7, 595, 1933.

56. WYE, SOUTH EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Insecticides and fungicides.—The spraying trial in the College plantation in which Bordeaux mixture was compared with "oil-Bordeaux" was continued. The oil used in the preparation of the "oil-Bordeaux" was a reasonably cheap grade of cotton-seed oil. In last year's trial expressed oil of mustard was used and the results were not as good as with ordinary Bordeaux mixture (1). "Oil-Bordeaux" was also used in trials for the control of pear scab in a commercial plantation at Faversham. The spraying of an orchard at Cranbrook with Bordeaux mixture resulted in 95 per cent. of the apples (mainly Bramley's Seedling) being free of scab.

Investigations have been continued into copper-containing sprays and modifications of Bordeaux mixture designed to simplify and hasten spraying operations (2). The comparison of the fungicidal efficiency of various protective fungicide-contact insecticide combinations has been made, using the potato as a test-plant (3). The investigation of the ovicidal action of hydrocarbon and glyceride oils has been carried out in collaboration with the Entomological Department. No significant correlation was found between the ovicidal efficiency of certain high-boiling petroleum oils and their degree of refinement or physical characters. The addition of high-boiling tar oils resulted in an increased ovicidal efficiency of the petroleum oil washes (4).

The fungicidal action of glyceride oils has been shown to be associated with the glyceride structure and to be markedly influenced by the type of emulsification (5).

Certain by-products from the refinement of petroleum oils have been examined to ascertain their suitability as spray spreaders, Numerous proprietary wetting agents have also been examined and one of them—"Sulphonated Loral" was found to be very promising.

Potash content of soils.—The *Aspergillus* method for the estimation of available potash in the soil has been further tested, particularly in connection with fruit-growing. The method has also been found to be of considerable service in dealing with questions of potash manuring. Upwards of 80 samples of soil, taken in connection with the "marsh spot" of peas investigation have been tested by the method.

Titles of papers issued during the year.

1. Martin, H.: The present uses and future development of spray spreaders. *Hort. Educ. Assoc. Yr. Bk.*, **1**, 76-84, 1932.
2. Austin, M. D., Jary, S. G., and Martin, H.: Some new insecticides and possible insecticide-fungicide combinations. *Ibid.*, **1**, 85-92, 1932.
3. Martin, H., and Salmon, E. S.: The fungicidal properties of certain spray fluids. X. Glyceride oils. *J. Agric. Sci.*, **23**, 228-251, 1933.

4. Martin, H.: Studies upon the copper fungicides. II. Some modifications of Bordeaux mixture designed to overcome practical difficulties in its application. *Ann. Appl. Biol.*, **20**, 342-363, 1933.
5. Austin, M. D., and Martin H.: The incorporation of contact insecticides with protective fungicides. Potato field trials, 1930-1932. *J. S.E. Agric. Coll.*, 32, 49-58, 1933.
6. Austin, M. D., Jary, S. G., and Martin, H.: Studies on the ovicidal action of winter washes, 1932 trials. *Ibid.*, 32, 63-83, 1933.
7. Goodwin, W., Martin, H., Salmon, E. S., and Ware, W. M.: The control of apple scab; Allington Pippin and Newton Wonder, 1932, *Ibid.*, 32, 95-107, 1933.
8. Furneaux, B. S.: In quest of the ideal fruit soil. *Hort. Educ. Assoc. Yr. Bk.*, **2**, 67-76, 1933.

57. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE

Soil and manurial investigations.—The investigations on the "lime requirement" of soils have been continued. The results obtained were communicated by Dr. A. M. Smith to the meeting of the International Society of Soil Science held at Copenhagen in August, 1933 (1).

The investigations which have been carried out during the past four years on seasonal variations in soil acidity have been continued; the results were communicated to the above Society by Dr. Smith (2).

The effect of the growing plant upon soil acidity and the relative changes in the composition of the soil solution are still being investigated and it is hoped that the results will be ready for publication in the near future. Meantime, the work dealing with the alterations in soil acidity by the application of lime or sulphur and the subsequent effects on the yield and composition of the crop have been completed and published (3).

The effect on the acidity of the soil of the application of the various fertilisers is obviously a subject of importance. In the past there has been a good deal of misconception as to what takes place, but as the result of recent work it is now generally agreed that superphosphate does not alter soil acidity while basic slag reduces it. In order to collect further evidence, the investigation of the effects of fertilisers on a number of typical soils is being carried out in the department.

An intensive study has been made of the technique of the method of estimating the manurial requirements of the soil by means of the fungus *Aspergillus niger*, and work has been completed in regard to the estimation by this method of phosphate deficiency of the soil (4). It is now proposed to make a similar examination of the method as employed for the estimation of potassium deficiency.

The investigation with relation to the nitrogenous top dressing of oats which has been going on for five years is not yet completed. A comprehensive field plot experiment was conducted in the summer of 1933, and the results of the analysis of the grain are now being carried out. In consequence of the variation in season in the period during which the experiment has been run, it should be possible to come to fairly definite conclusions regarding the value of delaying the top dressing of nitrogen in the ultimate composition of the grain.

Storage of Potatoes.—Experiments on the storage of new potatoes are being continued both in the laboratory and on a commercial scale, and it is anticipated that certain conclusions regarding the practicability of the scheme will be available early in 1934.

Silage.—Much interest has been shown by farmers recently in the changes brought about by the conversion of crops into silage; a considerable amount of analytical work of a rather complicated kind has been carried out in connection with silage made by farmers as well as with the new A.I.V. process which was experimented with at the College farm.

Composition of pastures.—The investigation into the effect of nitrogenous manuring on the composition of pasture has now been carried on for four years; detailed analyses of this year's samples are in progress and a report on the results of the four years' work will be made when the analyses are completed.

Composition of heather.—The investigation into the composition of heather is being continued. The analyses of the edible portions of the heather from different districts and of different ages carried out last year showed little difference in composition.

Composition of Milk.—The work in connection with the composition of milk from the pedigree herd of dairy cattle at the farm of the Institute of Animal Genetics (University of Edinburgh) at Shothead, Balerno, Midlothian, is being continued. Advantage is being taken of the samples provided to carry out determinations on the freezing point of milk, a factor which is now being used in connection with the detection of the addition of water to milk.

In recent years the question of the hardness of the curd produced by different kinds of milk has received considerable attention, particularly in the United States. It is suggested that milk giving a soft curd is more suitable for infant feeding than milk giving a hard curd. In response to applications from producers in the College area an investigation into the question has been started; the methods employed for the measurement of the hardness are not satisfactory and as the result of the work by Mr. McGillivray and Dr. Comrie definite improvements in the technique have been effected; a considerable number of samples has already been examined.

Titles of papers issued during the year.

1. Smith, A. M.: The estimation of the "lime requirement" of the soil. *Trans. 2nd Comm. I.S.S.S.*, A, 102, 1933.
2. ————: The variation in soil acidity. *Ibid.*, 106, 1933.
3. Smith, A. M., and Robertson, A.: The effect of lime and sulphur on soil acidity, crop yield and absorption of calcium and sulphur by the plant. *Trans. 4th Comm. I.S.S.S.*, 1933.
4. Smith, A. M., and Dryburgh, A.: A study of the technique of the aspergillus niger method of estimating soil fertility. *Ibid.*, 1933.

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58. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE

Soils.—The soil texture map for South Ayrshire (Sheet 14) was published by H.M. Geological Survey. Typical profiles were examined in detail and an area mapped on the basis of profile mineralogical examination, together with the chemical analysis was made upon a number of soils from Ayrshire and the results show promise in elucidation of origin and nature of parent material from which the soils have been derived.

Fertilisers.—The lime status of the soils of Wigtownshire has been examined. Experimental plots were examined to ascertain the relation between laboratory and field figures.

Basic slag.—Investigations of the constitution and chemical characteristics of basic slags have been continued. The value of the citric acid solubility test has been reviewed. Field trials were conducted to assess the manurial value of various types of slag and to estimate the recovery values.

Feeding trials.—Data relative to the effect of storage of potatoes and swedes were obtained in connection with feeding trials at Auchincruive. The composition of A.I.V. silage was investigated.

Titles of papers issued during the year.

1. McArthur, D. N., Whittles, C. L., and Jack, I. C.: Soil texture map, South Ayrshire. *H.M. Geol. Survey*, 1933.
2. Jack, I. C.: Study on soils of South Ayrshire.
3. McArthur, D. N., and Sneddon, J.: Constitution and chemical characters of basic slags. *Agric. Prog.*, **10**, 157, 1933.

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ENTOMOLOGY

59. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES

Winter spraying trials.—The study of the effect of winter washes on fruit trees, with special reference to the mild moist weather conditions prevailing on the western seaboard has been continued, and washes produced in the province tested against other and better known proprietary washes.

Control of plant pests.—Further experiments on the control of turnip flea beetles were carried out, and it was shown that under certain conditions, derris dusts provide an effective and economic method of control. Experiments also showed that derris dusts are the most effective methods of controlling the various cabbage caterpillars and the gooseberry sawfly.

Potato eelworm.—A special survey was carried out of districts where losses caused by the eelworm *Heterodera Schachtii* are severe. Although chemical control of this pest has proved of little value, the problem is becoming of such grave importance that arrangements have been made to carry out a series of experiments in the hope that some efficient means of control may be discovered.

Cestodes of birds.—The collection, identification, and study of parasitic worms of birds was commenced and is in progress. This is a subject which has received little attention in Great Britain, and offers scope for considerable work.

Grass disease of horses.—An investigation of grass disease of horses has been commenced. Observations carried out in other quarters have suggested that this obscure disease, whose cause has so far defied discovery, may be in some way connected with the *Sminthurus* population of the infective pastures. Since the disease occurs in South Cardigan and North Pembroke an intensive examination of the fauna of infective pastures, and of pastures on the same farms not known to be infective, was commenced, and is still in progress.

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60. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES

Ecology of potato aphides.—A comparative study has been made of the aphis population at successful seed-potato-producing centres, where there has been no marked increase in virus infection of

the stocks, with that at unsuccessful centres, where the spread of virus diseases has been rapid. The index figure of infestation at the successful centres has not exceeded 20 *Myzus persicae* per 100 leaves, whereas at the unsuccessful centres it has always exceeded 100 *M. persicae* per 100 leaves, and more often was of the order of 500-800 per same unit area.

The mode of hibernation and the main initial source of *M. persicae* have been ascertained. Investigations on the migration of alate individuals were commenced.

Sheep maggot fly.—Investigations on the sheep maggot fly have been extended and an attempt was made to ascertain whether the predisposition of sheep to attack by *Lucilia sericata* was inherited. 2,000 sheep were marked in lots of 50, but unfortunately the infestation was much below normal. There was definite evidence that a high percentage of ewe lambs attacked had the vulva " scabbed ". Larvae were bred on this scabby excretion covering the vulva of certain lambs.

Data was accumulated demonstrating the vital relationship of humidity in attacks by larvae of *Lucilia sericata*. Despite an exceptionally favourable temperature, attacks by sheep maggot fly were considerably below normal. Observations were made of heavy infestations of eggs on sheep which had hatched, but the larvae had subsequently shrivelled. Factors predisposing attack in the different breeds of sheep are being investigated. Experiments with varying strengths of naphthalene and lime sulphate applied as dusts did not prove successful in the control of this pest.

Collembola.—Progress has been made in the systematic study of Collembola and several additions have been made to the British list. Identifications of species causing damage to different crops have been made for several other workers.

Field trials.—The efficiency of calcium cyanamide, sulphate of ammonia and nitrate of chalk for the control of the potato eelworm (*Heterodera schactii*) has been demonstrated.

Successful control of red spider of apples (*Oligonychus ulmi*) has been obtained as the results of trials with a range of tar-oil-petroleum washes.

Titles of papers issued during the year.

1. Whitehead, T., Currie, J. F., and Davies, W. M.: Virus diseases in relation to commercial seed potato production. With a study of the aphid population on selected farms. *Ann. Appl. Biol.*, **19**, 4, 529-549, 1932.
2. Davies, W. M.: Ecological studies on aphides infesting the potato crop. *Bull. Ent. Res.* **28**, 4, 535-548, 1932.

61. BRISTOL UNIVERSITY

Control of the chrysanthemum eelworm (Aphelenchoides ritzema-Bosi).—In four heavily infested varieties, the cleansing of the " stools " with hot water sterilisation as compared with nicotine and maura meal extracts, was continued on a considerable scale and duplicated at Long Ashton Research Station and with two selected growers. These methods have yielded interesting and satisfactory results.

The behaviour and control of Heterodera schachtii.—Work on the pea strain, which was commenced in 1932, was continued on an extensive scale, and comprised glasshouse, garden and field trials. Considerable variety trials gave confused results and failed to reveal any varietal immunity, although several showed some resistance and will receive further trial. Other trials yielded valuable data as to the behaviour of this strain, since none of a wide range of crop weeds showed any susceptibility to infestation, whilst broad beans and vetches became heavily and red clover lightly infested.

With the potato strain further hopeful results with formaldehyde treatments will be followed up.

Flea beetles, distribution and control.—An initial series of field trials in all counties (but particularly in Somerset) and at seventeen centres has yielded interesting preliminary data. It would seem that the application of dusts does not fit in well with agricultural practice, neither were the results obtained very hopeful. A seed dressing made up at Long Ashton Research Station and comprising a mixture of paradichlorobenzene and naphthalene dissolved in a good grade of kerosene gave hopeful results and was well received.

Insect pests of hops.—A survey of these pests occurring in the Bristol Province was started and some progress has been made.

Titles of papers issued during the year.

1. Walton, C. L., and Kearns, H. G. H.: *Psila nigricornis*, Meig. as a pest of chrysanthemums. *Ann. Rep. Long Ashton Res. Sta.*, 95-96, 1932.
2. ————: Experiments on the control of the greenhouse Symphilid (*Scutigerella immaculata*). *Ibid.*, 96-101, 1932.
3. ————: The control of the loganberry and raspberry beetle (*Byturus tomentosus*). *Ibid.*, 39-52, 1932.
4. ————: The adult raspberry beetle as a cause of serious blossom injury. *Ibid.*, 53-85, 1932.
5. Walton, C. L.: Flea beetles. *Worcs. C.C. Agric. Quart. Chron.*, **I**, No. 2, Feb., 1933.
6. ————: A note on the control of the raspberry beetle (*Byturus tomentosus*), by means of a barium silicofluoride wash. *Ann. Rep. Long Ashton Res. Sta.*, 77-80, 1932.

62. CAMBRIDGE UNIVERSITY

Raspberry beetle (*Byturus tomentosus*).—Experiments on the control of this pest were carried out at three centres in the Isle of Ely and one in Cambridgeshire. The results obtained confirmed those of last year, viz., that this pest can be controlled by two sprayings of either nicotine sulphate or derris, together with a spreader. In addition this experiment showed that one spraying ten days after full bloom gave a very satisfactory control. Two dustings against the beetle also gave a very good control, as did two dustings against the larvae. On the three acres of loganberries, most of which were dusted experimentally last year, the grower continued dusting this year and so reduced the beetle that it was very difficult indeed to find an attacked fruit this summer.

Control of plum sawfly (*Hoplocampa flava*).—These experiments were carried out at four centres—two in Cambridgeshire, one in the Isle of Ely and one in Essex. Spraying with nicotine sulphate, lead arsenate and a spreader about a week after petal fall and again about a week later gave a marked reduction in the number of plums damaged. The resulting crop was much bigger on the sprayed trees and the growers are satisfied that this spraying was, under the conditions of the experiment, an economic proposition. Two growers in Huntingdonshire who carried out similar spraying obtained only about 40 per cent. control. Incidentally the plums from the sprayed plots were much cleaner than those from the unsprayed plots. This was brought about by a big reduction of the thrips population which caused bad markings on a large percentage of the unsprayed plums. Dusting alternate trees with naphthalene when 25 per cent., 50 per cent. and 75 per cent. of the blossoms were open also considerably reduced the sawfly infestation, but the experiment was on too small a scale to decide if it is likely to be an economic proposition.

Chrysanthemum bug (*Lygus pratensis*).—Observations have been made on the damage caused by this pest and also on the possibility of reducing this damage by spraying.

Apple blossom weevil (*Anthonomus pomorum*).—A preliminary experiment was carried out on the control of this pest by means of derris dust. No satisfactory results were obtained, possibly due to the wrong timing of the application and to insufficient dust.

Parsnip canker.—An attempt is being made to reduce this damage by controlling attacks of carrot fly.

Title of paper issued during the year.

Petherbridge, F. R., and Thomas, I.: The control of the raspberry beetle. *J. Min. Agric.*, **39**, 1017, 1933.

63. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES

Greenhouse white fly.—The parasite *Encarsia formosa* was again kept going successfully at several centres throughout the winter, and these were used as distribution centres from which growers requiring the parasite were supplied. Practically all the new introductions were successful.

Cockchafer control.—Cockchafer attack on market garden and farm crops was very serious during the year and trials were instituted with the object of assisting growers to combat this pest. Naphthalene of different grades from drained creosote salts to flake naphthalene were tried at six centres on a range of crops including grassland, mangolds, strawberries, potatoes and cabbages. It was found to give promising results when applied in the early spring immediately after the wintering larvae had returned to the surface. Later on dressings of over 10 cwt. per acre failed to give complete control although many grubs were destroyed. Possibly this partially unsuccessful result may have been due to the abnormally dry period, there being no rain sufficiently heavy to wash the insecticide in.

The best results were obtained by hand picking the grubs following cultural operations. From one area of $\frac{3}{4}$ acre over 100 lb. of grubs were collected, representing some 30,000 grubs per acre. This hand picking also would prove a cheaper operation usually than insecticide applications.

Warble fly control.—Demonstrations of the derris-soft soap treatment for warbles in cattle were made at four centres and satisfactory results were obtained in each case. An attempt was also made to determine which particular flies were responsible for " gadding " in cattle—whether the warble flies alone were responsible or whether the large blood sucking " gad " flies caused the cattle to gallop. Definite information was difficult to obtain, but observations indicated that *Tabanus bovinus* and *sudeticus* are not sufficiently common in South Wales to account for much of the gadding of cattle. The smaller bloodsucking flies such as *Haematopota* do not appear to disturb the animals much. *Hypoderma lineata* is less likely to cause gadding than *Hypoderma bovis.*

Titles of papers issued during the year.

1. Thompson, H. W.: Plant pests in Glamorgan. *Trans. Cardiff Nat. Soc.*, 64, 1933.
2. ————: Winter spraying of fruit trees. *Western Mail Ann. Agric. Sup.*, Jan., 1933.

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64. HARPER ADAMS AGRICULTURAL COLLEGE

Chrysanthemum eelworm (*Aphelenchoides Ritzema-Bosi*).—Investigations on this eelworm, which are still proceeding, have already led to important practical findings particularly those into

its control. An account of these investigations has been prepared for publication in the Journal of Helminthology.

The 1931-32 experiments suggest that control can be obtained by submitting chrysanthemum stools, in autumn and before cuttings are taken, to water at 110° F. for a period of not less than 30 minutes. It appears, however, that the adoption of such method would demand special attention to the stools in autumn, particularly in the case of early flowering varieties, to compensate for the retardation in the appearance of cuttings.

The 1932-33 experiments give further indications of the value of the hot water treatment and are in general agreement with those of 1931-32. In view of the results obtained in these later experiments, it appears that the retardation in growth produced by submitting the stools to water at 110° F. can be overcome provided the treatment is carried out when the cuttings are ready to be taken and the duration of the immersion is 15 minutes. These experiments are to be regarded as preliminary ones, and further extensive trials must be conducted over several seasons before final conclusions can be reached.

Control of cabbage root fly.—Previous field experiments had given definite indications of the value of corrosive sublimate solution and commercial naphthalene powder against the cabbage root fly. These substances were further tested in experiments carried out during 1932 and 1933. In both years the control treatments were tested on cauliflowers. From the results obtained it appears that corrosive sublimate solution to which has been added sufficient soil to convert it into a fairly thick " cream " cannot be recommended for control of the cabbage root fly and that the use of naphthalene is dependent to a very marked extent on climatic conditions. These considerations point to the conclusion that corrosive sublimate applied as a fluid in three applications offers the most satisfactory solution of the problem of cabbage root fly control.

Winter washes.—Continuing the spraying trials of 1930-31 and 1931-32, the following washes were used in 1933 and gave excellent control of aphis, sucker and winter moth caterpillar and had no injurious effect on foliage or fruit buds. Washes (*a*), (*b*) and (*c*) also gave a good control of apple capsid bug.

(*a*) Two parts mineral oil emulsion plus one part Long Ashton modified tar-oil wash at 10 per cent. combined strength.

(*b*) Two parts mineral oil emulsion plus one part standard tar-oil wash at 10 per cent. combined strength.

(*c*) Similar to (*b*) except that the washes were applied separately; tar-oil in January followed two months later with the mineral oil emulsion.

(*d*) Aromatic wash at 10 per cent. strength.

The washes (*a*), (*b*) and (*d*) were applied towards the end of January and beginning of February.

Bionomics and control of the mangold pigmy beetle (Atomaria linearis).—Trials were continued with a view to obtaining further evidence as to the value of the phenol-magnesium sulphate solution treatment of seed. No reliable results were obtained as the beetle failed to do any appreciable damage at the centres selected.

Carrot and onion flies.—Field experiments indicate that the exact number of applications and amount of " drained creosote salts " to use can not be easily established as these apparently are greatly influenced not only by weather conditions but also by the nature of the soil and time of sowing of the crops. A progress report on these five years investigations, which are being continued, is in course of preparation.

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65. LEEDS UNIVERSITY

Potato eelworm.—Investigations on the chemical control of the potato eelworm (*Heterodera Schachtii*) by means of plot experiments at Cawood and North Cave were continued. The effect of mercuric chloride used as a dressing at different times of the year on sandy soil heavily infested with eelworm has been examined. It has been observed that mercuric chloride applied to the soil before planting appears to reduce the degree of infestation of the root by cysts of subsequent potato crops as far as can be judged by naked eye examination of specimen plants during the growing season. This chemical, however, has a serious effect upon the germination and early growth of the plants when applied a short time before planting. Autumnal and winter dressings, on the other hand, have a stimulating effect upon the crop, the plants remaining healthy and vigorous throughout the growing period. The yields from plots laid down in triplicate dressed in the previous autumn and winter were very considerably higher than those from untreated plots and the reduction in number of cysts on roots and tubers at lifting time was very marked on all plots treated with mercuric chloride.

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66. MANCHESTER UNIVERSITY

Biology and control of fruit infesting sawflies.—Successful control of apple sawfly, *Hoplocampa testudinea*, kl. was obtained with two applications of nicotine wash, one immediately after petal fall and the second 3-4 days later. The spray was directed on the trusses of fruitlets from above and driven well into the open calices. Under 5 lb. of apples per plot was gathered from the unsprayed plots at harvest and an average of 440 lb. of fruit was obtained from the plots that had been sprayed.

Studies dealing with the occurrence and habits of the plum fruit sawfly, *H. flava* L., have shown that this species is a serious pest

in the damson growing areas in the North West of England, and that when plums and damsons are not available the insects will breed on the sloe, *Prunus spinosa*.

Control of Scutigerella in glasshouses.—Glasshouse crops, notably tomatoes and lettuce, have recently been seriously attacked by the symphylid, *Scutigerella immaculata*, Newport. Preliminary investigations on the habits and control of this species have been carried out and promising results have been obtained by using carbon bisulphide emulsion applied at the strength of 1 in 50 to the soil at the base of infested plants. The symphylids were killed by the emulsion at this strength and the plants immediately began to form a new root system in place of that destroyed by the pest.

Investigations on "potato sickness".—Work on the value of a wider rotation in reducing the intensity of attack by the root eelworm, *Heterodera Schachtii*, has been continued during the year with the help of the Superintendent of the Ormskirk Potato Testing Station.

Control of insects injurious to basket willows.—Further observations have been made on the value of cultural and similar operations in reducing losses caused by injurious insects and a paper on this subject is in the press.

Titles of papers issued during the year.

1. Miles, H. W.: Dusting for the control of apple sawfly. *J. Min. Agric.*, **39**, 12, 1125-1128, 1933.
2. Miles, H. W., Thomas, I., and Hey, G. L.: On *Hoplocampa flava L.*, the plum sawfly. *Ann. Appl. Biol.*, **20**, 4, 722-730, 1933.

67. MIDLAND AGRICULTURAL COLLEGE

Bird problems.

(a) *Rook Survey.*—A second survey of the five counties of Nottinghamshire, Leicestershire, Rutland, Derbyshire and Lincolnshire has been completed. The two surveys show that the population is more or less stationary. The sites of rookeries, chiefly the smaller ones, often change. Of the 1,421 rookeries in the first survey, 201 sites had been abandoned, and 300 new ones occupied. The appeal of a grass paddock alongside a rookery is emphasised. Only on one large area, namely the Lincolnshire wolds, where there is an abundance of snails as food, does the density of the rook population surpass that on the rich grazing lands of Leicestershire. A preliminary survey of the major rookeries or winter roosts has also been made.

(b) *Feeding problems.*—Experiments have been made on the feeding of young rooks to ascertain the amount (weight and volume) of food consumed. Attempts are being made to find the

causes of the heavy mortality which ultimately results in a fixed population. The reason for the apparent necessity of a grass paddock is being studied and the feeding ranges of the colonies.

(c) *Starlings.*—A survey of the winter roosts of starlings was carried out in five counties with the co-operation of the county education staffs. Of the 106 roosts located, 60 were in Lincolnshire. The number of starlings is so large that their destruction is out of the question. Luckily it is only in bad foggy weather that they all feed in the vicinity of the roosts, usually they extend over a range of many miles.

Cheese mites.—In conjunction with the advisory chemist and the head of the dairy department, large scale experimental fumigations with ammonia have been carried out in commercial cheese stores. Stiltons are extensively produced in this area, and every season damage is caused by the mite *Tyroglyphus longior.* The general results appear to be very satisfactory. Ammonia gas kills a high percentage of the mites, is non-inflammable, and relatively cheap. If exposure is too prolonged or the concentration excessive there is a slight tendency to produce a sticky coat.

Pea aphis.—*Macrosiphum Pisi* has been very destructive to crops in Lincolnshire. Experiments were made in co-operation with one of the canning factories. Nicotine and pyrethrum washes were used. Although a certain amount of control was obtained, yet sufficient aphides were left well protected near the young tips, so that considerable damage was still caused. Should the pest reappear control experiments will be continued.

Red bud borer (*Thomasiniana oculiperda*).—This pest has appeared this year in large numbers where no measures are taken to combat it. Extensive trials on a large nursery during the last three seasons show that damage can be completely prevented. Vaseline applied over the inserted buds prevents egg laying and subsequent damage. This remedy can be applied to both bushes and standards, but a simpler method for bushes which gave good results is to earth up the bush until the soil completely covers the bud and its coverings, the soil being again levelled in the late Autumn.

Carrot fly.—Field experiments were laid down on the two farms in Lindsey, and the dressings applied. The material under test was green tar oil absorbed in North African phosphate. No attack appeared on either the plots or controls.

Millepedes.—Experiments indoors and in the open plots showed that a mixture of ortho and para-dichlorobenzene at the rate of 2 cwt. per acre rapidly and completely destroyed these pests. A field in the Isle of Axholme which persistently suffers from these pests has had one part dressed at this rate. Another part of the field has been dressed with mustard bran. The results will not be available until the Spring.

Titles of papers issued during the year.

1. Roebuck, A.: Survey of rooks in the Midlands. *British Birds*, **27**, 1, June, 1933.
2. ————: Measurements in nature; or the toll of insect pests on the farms of Lindsey during 1932. *Lincoln. Nat. Union Trans.*, 1932.
3. ————: Eelworms. Their importance to horticulture. *Derbyshire Farmer*, **13**, August, 1933.
4. ————: Leatherjackets (*Tipula species*). *Ibid.*, **13**, July, 1933.

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68. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY

Plum sawfly (*Hoplocampa flava*) *on damsons.*—In April, 1933, an investigation was carried out in order to determine the species of plum sawfly occurring in the damson growing districts in Westmorland and Cumberland. Hitherto the species had been reported from Westmorland and Cumberland as *H. fulvicornis.*

Spraying trials against red spider (*Oligonychus ulmi*).—Trials with four new kinds of winter washes were carried out in a plantation of young damsons. The trees since receiving winter washes were observed to become more heavily infested with red spider (*Oligonychus ulmi*), and indeed, this result has been observed in other orchards in the Lyth Valley. It was shown that two of the washes were efficient against red spider and that they also caused reduction of aphides.

Raspberry beetle (*Byturus tomentosus*).—An experiment was tried against this pest with two proprietary dusts and two proprietary washes. One of the washes which contained barium silicofluoride was tried on a short section only, but gave promising results, and it is proposed to make a more extensive trial with this wash next season.

Apple Sawfly (*H. testudinea*).—Preliminary trials were made with two dusts, one containing derris, the other naphthalene, and though benefit seemed to follow the three applications given, it is considered that further trials should be made to obtain definite results.

Title of paper issued during the year.

Gray, R. A. Harper, and Brooks, H. E.: Winter spraying trials against the apple capsid bug on mixed varieties of apple trees. *J. Min. Agric.*, **40**, 7, 630-635, 1933.

69. READING UNIVERSITY.

Strawberry pests (6).—The field investigations referred to in previous reports have continued. Further valuable information as to the control of the blossom weevil, *Anthonomus rubi*, by means of dusting has been obtained, a control of from 75 per cent. to 90 per cent. being consistently recorded. The technique for subjecting strawberry plants to hot water treatment has been improved.

Yellow stripe in narcissus.—Work on this " virus " has been continued and extended. No outstanding developments have occurred.

Bulb scale mite, Tarsonemus approximatus (Var. Narcissi).—The bionomics of this pest have now been studied in detail and a publication is in course of preparation.

Chrysanthemum eelworm, Aphelenchoides ritzema-bosi.—This nematode has been extensively studied during the past three years (7). Effective control measures have been devised.

Stem and bulb eelworm, Anguillulina dipsaci.—Studies of the biology of this nematode continue. A development has arisen in that English iris, *Iris Xiphiodes*, has become a favoured host plant to an extent that in Holland, U.S.A. and in this country, infested and useless stocks outnumber healthy ones. Investigation of the problem continues.

Titles of papers issued during the year.

1. Hodson, W. E. H.: The large narcissus fly, *Merodon equestris*, Fab. (*Syrphidae*). *Bull. Ent. Res.*, **23**, 4, 429-448, Dec., 1932.
2. ————: Hot water treatment and its application to the control of certain plant pests. *Agric. Prog.*, **10**, 180-183, 1933.
3. ————: Eelworms. I. The stem and bulb eelworm, *Anguillulina dipsaci*. *Estate Mag.*, 198-201, March, 1933.
4. ————: Eelworms. II. The " cockle " in wheat. *Ibid.*, 356-358, May, 1933.
5. ————: Eelworms. III. Species destructive to garden and glasshouse plants. *Ibid.*, 607-612, Aug., 1933.
6. ————: Strawberry pests and diseases. *Fruitgrower*, **75**, 1938, Feb., 1933.
7. ————: Chrysanthemum eelworm, *Aphelenchoides ritzema-bosi*. *Hort. Educ. Assn. Yr. Bk.*, 85-89, 1933.

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70. SEALE-HAYNE AGRICULTURAL COLLEGE

Bulb eelworm (Anguillulina dipsaci).—(a) Investigations on the subject of hot water treatment and its relation to both eelworms and bulb have reached the stage when definite conclusions can be drawn (1). Briefly, the results of the work are as follows :—

(i) The time taken to kill the bulb eelworm and its eggs in water at 110° F. is 17 minutes. The eggs are more easily killed than the worms.

(ii) The times taken to raise the whole of a bulb to a temperature of 110° F. (in water of that temperature) have been determined and correlated with size and character of the individual bulbs.

By the combination of the facts set out above it is shown that bulbs may be treated for varying periods according to size and that these times of treatment are in the majority of cases less than the standard treatment of three hours hitherto employed. The shortened periods of treatment have been shown to effect a great saving of time to growers and thus have enabled farmers to treat large quantities of bulbs at the optimum period of the treating season. It has also been demonstrated that the shortened periods also control mites and the larvae of the Narcissus Flies.

As far as it has gone (and for the range of varieties dealt with), the work also shows that flower damage practically disappears when bulbs are treated for periods not longer than is necessary to kill bulb eelworm. Shortened periods do not reduce leaf damage, such as speckling and mottling. The laboratory investigations have been confirmed by the experimental treatment of healthy and diseased bulbs; it is important that it should be realised that commercial bulb baths are not necessarily accurate enough to employ shortened periods of treatment.

(b) *Treatment of soil infected by eelworm.*—None of the various substances tried as soil dressings, as a means of preventing the infection of bulbs planted in eelworm infected land, was found to be effective.

(c) *Behaviour of eelworm under bulb-forcing conditions.*—The peculiar distortions of the flowering stems of certain varieties of bulbs forced under glass, as the result of eelworm attacks, were found to be due to direct infection of the flowering stems by the worms.

Bulb flies (*Merodon equestris and Eumerus spp.*).—An experiment was carried out in West Cornwall to determine whether the damage caused by the larvae of these flies could be prevented by means of dusts. Two dusts were tried, a commercial naphthalene dust and a dust made from lime and creosote of a type which could be made cheaply by the growers themselves. The dusts were applied during the period that flies were ovipositing, but before the foliage could be raked off, and the bulbs placed beyond the reach of the flies by means of a covering of soil. Flies were present in large numbers. The dust was so applied that the foliage and the ground were well covered; the holes in the soil left above each bulb also received the dust. It was considered that the dusts might prove effective in two ways, viz. (i) the dusts would act as deterrents and so prevent oviposition. (ii) In the event of eggs being laid the young larvae would have to crawl through the dusts in the holes before reaching the bulbs and the dusts might be expected to deter, or even kill, them.

The bulbs treated with dusts were lifted at the correct time. Bulbs attacked by fly larvae were practically absent and the use of dusts therefore appears to show great promise. Further and more extensive experiments will be carried out during the coming season.

Violet leaf and flower aphis (*Myzus ornatus*).—This aphis, which was only described last year, has continued to attack violets. The area over which it is found has been greatly extended and few violets were free from attack. During the previous season the aphis was found to leave violets towards the end of the summer but the alternative host-plants could not be found. During the current year these hosts have been discovered and have proved to be buttercups and hedge mustard.

Violet eelworm (*Aphelenchoides olesistus*).—The first case of eelworm damage investigated was at Dawlish in November, 1932. Attacked plants are much dwarfed, the leaves small and deformed, and the leaf stalks tapered and thickened; the flower stems are shortened, and the flowers weak. Runners from affected plants are frequently similarly attacked. Joint work on this pest has been undertaken in collaboration with Dr. T. Goodey, of the Institute of Agricultural Parasitology, and a paper dealing with the work accomplished has been published.

Investigation has shown that the eelworm is of widespread occurrence and is in all probability one of the principal causes of the general deterioration of violets which has been remarked upon by many violet growers, particularly in Cornwall. Preliminary experiments have shown that it is likely that the treatment of runners with hot water before planting will enable growers to overcome their difficulties with regard to this pest.

Soil relations of abnormal types of strawberry plant.—As the result of three seasons work, definite results have been obtained with regard to the fluctuation of nitrate nitrogen in the soil from amongst the feeding roots of healthy and abnormal plants. As a rule, the amount of nitrate nitrogen is found to be very high in the case of diseased plants (particularly so in the case of " red plants " and " cauliflower disease " plants) as compared with healthy plants. " Red plants " seemed to be able to increase the amount of nitrogen in addition to being unable to take it up from the soil. These facts suggest as a possible theory that nitrifying bacteria may be stimulated in some way in the region of " red plants," which latter are, however, unable to benefit from this abnormal supply under ordinary conditions.

An experiment was carried out in which healthy and " red plants " were grown in sand culture and each series received the same amount of nitrate nitrogen. The object of the experiment was to check the facts found in the field, and it was expected that leaching of the sand and estimation of nitrate nitrogen would show that the healthy plants would have taken up more nitrogen than the

" red plants." Actually the reverse was found to be the case, but the " red plants " produced healthy leaves. This experiment suggests that the condition of the plants may partly be due to their inability to take up nitrogen, and that tearing or breaking of roots during lifting and transplanting has enabled the plant to take up nitrogen. Further work is needed before the significance of the results obtained can be estimated.

Hot water treatment of strawberry plants.—Satisfactory experiments have been carried out during the months August-March, and it is seen that good results are obtained at any time during the period, so long as planting conditions are satisfactory. The most usual time and temperature employed has been 20 minutes immersion in water at a temperature of 110° F. Various observations, however, suggest that the plants might, with advantage, be treated for 30 minutes in order to effect a complete kill of eelworm (A. fragariae). The hot water treatments have been found to kill aphis, red spider and tarsonemus mites.

Potato " sickness " (Heterodera Schachtii).—(a) *Manurial experiments.*—At one centre, soil analysis showed that lime was present in excessive quantities and that nitrogen was deficient. Heavy dressings of Farm Yard Manure were found to be beneficial, but dressings of 6 cwt. per acre of calcium cyanamide yielded the best results, a good crop of potatoes being harvested. The effects were clearly indirect since eelworm cysts were present on the roots of the plants on all plots.

At another centre, the potash content of the soil was very low and the phosphatic figure was abnormally high. Observations during the previous season showed that plants were markedly better where a large fire had been lit, an effect probably resulting from an increase of potash, coupled with partial sterilization of the soil. Accordingly potatoes were again grown and half the plot dressed with 10 cwts. of sulphate of potash to the acre. A very marked improvement was seen, but here again, eelworm cysts were present on both treated and untreated plots.

(b) *Hot water treatment of seed potatoes.*—Since numbers of potato growers have not yet experienced any difficulties with regard to potato sickness on their land, an investigation was carried out to determine to what extent eelworm cysts could be found in samples of seed potatoes from outside districts. Samples of the debris from sacks of seed potatoes were examined, and eelworm cysts were found. Experiments were also conducted to see if seed potatoes would grow and yield satisfactorily after hot water treatment. Seed potatoes were treated for periods of 20, 30, 60, and 90 minutes in water at a temperature of 110° F. In all cases the potatoes grew satisfactorily as compared with those untreated and the crops were all good. It is of interest that the shortest treatment (20 minutes) gave nearly double the crop produced by the untreated seed. Information is not yet available as to the exact time required to kill

eelworm cysts in water at a temperature of 110° F., but it is unlikely to exceed 60 minutes.

Broccoli seed pests.—Observations have been made on broccoli seed weevil (Ceutharrhynchus asimilis) and on blossom beetles (Melegethes aeneus). It has not been possible to devote much time to a study of their life histories, but the type of damage has been studied, and the relative importance of the pests has been assessed. No spraying or dusting trials have been carried out, but suggestions have been made to growers and observations made. Derris dusts seem to offer the best means of control.

Title of paper issued during the year.

Staniland, L. N.: Treatment of narcissus bulbs with hot water. *J. Min. Agric.*, **40**, 4, 343-355, July, 1933.

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71. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY

Control of the strawberry blossom weevil (Anthonomous rubi Herbst).—Field experiments with dusts containing rotenone and a dust containing sulphur-lead arsenate, have been continued. The degree of control obtained was small. Laboratory scale trials were made with the same two dusts and with barium fluosilicate and pyrethrum washes. None of these insecticides showed more than 50 per cent. toxicity.

The ovicidal action of various oil emulsions as winter washes.—Laboratory trials against eggs of the common green capsid (*Lygus pabulinus*) were continued on the same general lines as in the two previous years and field trials against the same insect and against the eggs of the apple capsid bug (*Plesiocoris rugicollis*) have also been carried out. The tar-petroleum wash which has previously given very satisfactory results against the common green capsid on currants has been used commercially by two growers on fields totalling about 20 acres of red and black currants. The results have been consistently good and the degree of control obtained very high.

Some new insecticides and insecticide-fungicide combinations.—This work again has been to some extent a continuation of that reported last year, but no field scale trial has been included. The hop-damson aphis (*Phorodon humuli*), the nettle aphis (*Macrosiphum urticae*) and the bean aphis (*Aphis rumicis*) have mainly been used as test insects but a number of trials on the fruit tree red spider (*Oligonychus ulmi*) have been included. The experiments were all of the precision type, involving actual counts of the numbers of insects and mites and about twenty-five different substances, spread over some 150 tests, have been used.

Pyrethrum.—The fourth crop was harvested from the experimental plot. Selection and propagation of certain type plants has been

carried out and observations made on the effect of varying distances of planting.

Chalcid parasite (Aphelinus mali) of the woolly aphis (Eriosoma lanigerum) in the field.—The parasite has been liberated in two badly attacked orchards and has become successfully established.

Life history and control of the apple fruit miner (Argyresthia conjugella).—Owing to the serious nature of attacks in the vicinity of Canterbury last year, it was decided to study this insect. Frequent observations were made in affected orchards and neighbouring woods and from material collected the life history was followed through in the laboratory. The attack in the field was negligible this year on apples, but the berries of mountain ash were plentiful in the vicinity and the attack was common on them. Preliminary control experiments were carried out in the laboratory with success.

Insect and allied pests of cultivated mushrooms and their control.—This work, commenced in 1930-1931, has been continued. Investigations have mainly been concentrated on the biology of *Sciara* spp. and in particular *Sciara fenestralis*, a species not hitherto recorded on mushrooms. The life cycle is short, being completed in from twenty-nine to forty-four days and a series of attacks may therefore take place during the cropping period of a mushroom bed. Certain species of *Phora* have also been studied.

Control methods on a laboratory scale and also on beds on the College farm have been carried out, using nicotine, derris and pyrethrum products. It would appear that nicotine used in the early stages of attack by *Sciara* spp. will give a considerable degree of freedom. Pyrethrum also promises to be worth further investigation, especially in certain cases.

Potato eelworm (Heterodera Schachtii).—Attempts to control this eelworm were made at two centres, one in Surrey and the other in Sussex, using crude naphthalene on the lines of experiments carried out elsewhere in the country. The soil was treated with crude naphthalene (drained creosote salts) which was ploughed in to a depth of about 7 inches a fortnight before planting, a dressing of 6 cwt. per acre being employed. In part of one experiment an equal quantity of hydrated lime was mixed with the naphthalene. In neither case was appreciable benefit derived from the treatment and the crop was little better than that obtained from neighbouring untreated soil, the attack by eelworm being heavy, though cysts were not quite as numerous on the treated plots. On the soils in question it would appear that this treatment does not give results which warrant the expenditure entailed.

Control of wireworms in new gardens.—A proprietary soil fumigant dug in at the rate of 4 oz. per square yard gave a very high kill of the wireworms present. The germination of seeds sown on treated land was adversely affected.

Titles of papers issued during the year.

1. Austin, M. D., Jary, S. G., and Martin, H.: Some new insecticides and possible insecticide-fungicide combinations. *Hort. Assn. Yr. Bk.*, 1, 1932.
2. ————: Studies on the ovicidal action of winter washes. *J.S.E. Agric. Coll.*, 32, 63-83, July, 1933.
3. Austin, M. D., and Martin, H.: The incorporation of contact insecticides with protective fungicides. Potato field trials 1930-32. *Ibid.*, 32, 49-58, July, 1933.
4. Austin, M. D.: A note on *Lygus pabulinus*. *Ibid.* 32, 168-170, July, 1933.
5. Austin, M. D., and Jary, S. G.: Investigations on the insect and allied pests of cultivated mushrooms. I *Sciara fenestralis* Zett. *Ibid.*, 32, 59-62, July, 1933.
6. Austin, M. D.: The insect and allied fauna of cultivated mushrooms. *Entom. Mthly. Mag.* I.—69, Jan., 1933 and II.—69, June, 1933.

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72. ABERDEEN: NORTH OF SCOTLAND COLLEGE OF AGRICULTURE

Cabbage root fly.—A large acreage of turnips and swedes is badly damaged every year by this fly (*Hylemyia brassicae* Bouché) in sandy regions chiefly fringing the N.E. coast. Last year, experiments to control the fly were carried out on a field scale at one farm. The results of the experiments were inconclusive, but it is arranged to experiment this year on a field scale in a wider area.

Sheep maggot flies.—In conjunction with the Zoology Department of Aberdeen University and the Rowett Research Institute, sheep maggot flies are being investigated with the intention of finding more satisfactory means of control than are usually adopted at present. Fly traps were set up on specially selected sites amongst sheep pastures and the trapped flies were collected, classified and counted twice weekly. The importance of the site of the trap is clearly demonstrated by the variations in numbers and in the species of flies caught at the different sites. The catches of the traps afford some data for attempts at controlling sheep maggot flies by means of traps.

Insecticides.—Various insecticides were tested for the control of red spider, whitefly, apple sucker, aphididae and raspberry beetle. The insecticides included winter washes: tar distillate sprays with different combinations of sulphonated mineral oils and selenium dissolved in lime sulphur wash. Summer washes: pyrethrum, rotenone, caustic soda and oleic acid with different oils; also sulphide lye mixtures.

Title of paper issued during the year.

Morison, G. D.: Thymol and honey-bees. *Better Beekeeping*. 7, 6-8, October, 1932.

73. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE

Progress has been made with the investigation of British horse-flies of the family Tabanidas. The study of the cleg (*Haematopota pluvialis*) has been almost completed and a commencement has been made with the habits and life-histories of four other species including *Tabanus fulvus*, *T. sodeticus*, *T. montanus* and *T. distinguendus*. The material for this study has been collected mainly in the vicinity of Edinburgh, Perthshire and Inverness-shire. In the two latter counties the flies are a live-stock pest of prime importance during July and August.

N

MYCOLOGY AND BOTANY

74. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES

Control of bunt in wheat.—This trial is to be continued over a number of years using the same variety of wheat and the same strain of bunt. In the present series the untreated plots were not heavily infected. Complete control was obtained by formalin (1 : 480) and Agrosan, but 2½ per cent. copper sulphate had a depressing effect on germination and final yield.

Dry treatment of oats.—These experiments were continued on a larger scale. Striking results were obtained at a highland centre, the increase in the number of seedling establishment amounted to 83 per cent. The beneficial effect of the treatment was not so significant at a lowland centre where the advantage recorded was only 2 per cent.

Dry treatment of grass seed.—The results obtained by treating oats suggested that similar benefits might be expected by dressing various species of grass seed. A trial was, therefore, arranged at the Welsh Plant Breeding Station with the following varieties of grasses : cocksfoot, timothy, ryegrass and red fescue. Seed of timothy and red fescue are naturally slow in forming a sward and an improvement in germination might assist in an early establishment of these species in a seed mixture. Plots of each variety were laid out but at present there is no difference between the treated and untreated seed.

Control of Finger and Toe in Brassicae.—Mercuric chloride (1 : 2000) has given good results against finger and toe in past experiments, but owing to its poisonous properties great care must be exercised in its use, and accordingly trials with non-poisonous substances have been carried out. Lime sulphur (1 : 40) and 0·25 per cent. washing soda when tested against finger and toe in broccoli did not give satisfactory control of the disease. The growth of the treated plant was inferior to plots treated with mercuric chloride, and little better than control or untreated plots. Other experiments laid down during the summer were ruined by the prolonged drought.

Cluster Cup Disease (P.Pringsheimiana) *in Gooseberries.*—Inoculation experiments with aecidiospores failed to reproduce the disease on a number of species of carex which are reported to be alternate hosts of the fungus.

Title of paper issued during the year.

Davies, D. W.: Control of finger and toe in brassicae. *Brecon and Radnor Quart. Gaz.*, **1**, 1, 1933.

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75. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES

Virus diseases of potatoes.—A study of these diseases—and in particular leaf roll—continues to form the main line of investigation. A comparison of the rates of respiration of healthy and infected plants throughout the life cycle has been completed (2). The claim made by the German workers Bechhold and Erbe that degeneracy could be assumed in a tuber in which an inserted strip of copper failed to cause blackening after a period of incubation, has been examined in some 500 tubers of seven varieties. After improvements in technique had been made, a clear difference in the reaction of individual tubers has been found, but its association with virus freedom or infection has not yet been substantiated. Further work is in progress. In connection with the seed potato scheme in North Wales, the problem of the initial infection of a crop is being studied. Four separate questions are involved in this work, i.e., (*a*) the proportion of infected to non-infected alatae of *Myzus persicae* which migrate to brassicae from potatoes in autumn; (*b*) the possibility of brassicae " carrying " the virus over the winter; (*c*) the proportion of infected to non-infected alatae of *Myzus persicae* reaching potatoes in early summer; and (*d*) the relative importance to be attached to the initial aphis infestation as compared with subsequent movement and multiplication in the crop, or later infestation from external sources. This work is well in hand, but no results are available.

Diseases of swedes and turnips.—In continuation of investigations of diseases of roots, the following points have been, or are being, studied: (*a*) the technique of field trials to ascertain the comparative value to the farmer of swede varieties, apart from the disease resistance (1); (*b*) the keeping power of thirteen varieties of swede and turnip after a severe attack of mildew and swede midge, and the meaning to be attached to the term " maturation " in swedes; (*c*) the effect on cropping power and disease incidence of varying the distance at which swedes are " thinned." The infection of swede seed with the dry-rot fungus, to a minute extent, has been confirmed, and the correlation of this with field infection is being studied. The association of a *Phoma* on the weed redshank with a dry-rot on swede has been established and

further work is in progress. The effect of various methods of seed disinfection with swede, mangold and oats has been begun, but the dry season of 1933 has prevented definite conclusions being drawn; the work is being continued.

Methods of controlling finger and toe are under investigation. Co-operative work with several advisers on the value of mercuric perchloride is about to be published. Trials have been laid down on two different kinds of soil to ascertain whether the effect of lime is directly fungicidal to the spores or indirect in altering the texture and reaction of the soil. The trials, which will continue for three or four years, will also show the relative susceptibility on each soil of cabbage, cauliflower, brussel sprouts and swedes.

Titles of papers issued during the year.

1. Whitehead, T.: The value of field trials with swedes. *Welsh J. Agric.*, **9.**, 208-224, 1933.
2. ————: The respiration of healthy and leaf-roll infected potatoes. *Ann. Appl. Biol.*, **21**, 1, Feb., 1934.

76. BRISTOL UNIVERSITY

Die-backs of apple trees.—The common *Cytospora* of apple trees has been shown to be the imperfect stage of *Valsa ambiens*, and it has been demonstrated that it can invade healthy trees when once established in dead areas. This fungus is apparently capable of causing much injury to moribund trees (11).

The role of certain other semi-parasitic fungi is being investigated.

Fruit spots and fruit rots.—Little work has been done in England on the biology and control of fruit spots and fruit rots, and since it appears that they may become increasingly important a systematic study has been commenced. So far *Phytophthora Syringae* and *Gloeosporium album* have been investigated. Other fruit spotting fungi common in the south-west of England are now being studied.

Strawberry root rots.—A systematic examination of root rots of strawberries has been undertaken. Many fungi have been isolated from plants in the various localities. Field trials of control measures have been laid down.

Virus diseases of small fruits.—Since little knowledge exists relative to the insect vectors of virus diseases of small fruits in this country, an attempt is being made to determine some of these, e.g., raspberry mosaic, reversion disease of black currants, and strawberry diseases. Stocks of seedlings are being raised under sterile, insect free conditions.

Asparagus diseases.—None of the trials with chemicals for the control of violet root rot (*Rhizoctonia Crocorum*) have been

markedly successful. The asparagus strain of the fungus has not yet been found on any other crop plants. Pure culture inoculations indicate that *Zopfia rhizophila* is only very slightly parasitic. A crown rot associated with *Fusarium* sp. and a spotting of the "bower" associated with a pycnidial fungus are also under investigation.

Diseases of beans.—Other *Fusaria* have been isolated from dwarf bean plants affected with foot rot, and their pathogenicity is under investigation. Variety trials have also been carried out.

It has been found that although runner beans are not usually severely infected with halo blight, severely infected seeds may produce a severe seedling blight.

White Rot of Onions (*Sclerotium cepivorum*).—The control of this disease on winter onions is being attempted by the application of fungicides to the drill during seed sowing.

Lettuce ring spot (*Marssonina panattoniana*).—Fungicidal treatments have been of little value but the varieties "Arctic" and "MacHattie's Giant" have been found to be rather resistant.

Mint rust (*Puccinia Menthae*).—The oecidial stage of *Puccinia Menthae* causes much damage to forced mint in the Province. Further trials have again shown that thorough washing of the plants in water before planting in the greenhouses is a valuable means of control. A late spraying with a 5 per cent. tar oil winter wash is also of value. The species and varieties of mint grown commercially have been identified with the help of Dr. Fraser of Kew and their susceptibility is being examined.

Diseases of peas.—"*Sickness*" (*Heterodera Schachtii*) is now being investigated. None of the pea varieties in the trials have been found to be markedly resistant. Broad beans, vetches, and red clover are susceptible to the pea strain.

Foot rots caused by *Fusaria* (especially those of the *Martii* group) are very prevalent in the Province, either alone or in association with the *Heterodera*. Extensive variety and other trials have been carried out. Certain organic mercury seed treatments were found to provide effective control of leaf and pod spots and foot rots (*Ascochyta Pisi* and *Mycosphaerella pinodes*) in pot experiments, and field trials have shown that they tend to increase the yield.

A transmissible mosaic disease and a bacterial disease (*Bacterium Pisi?*) are also under observation.

Potato sickness.—Consistent control of the nematode *Heterodera Schachtii* has been achieved by watering the soil, before planting, with formalin. This year striking results were achieved.

Fusarium wilt of asters has been shown to be due to *Fusarium* spp., which are being identified. Seeds of resistant varieties were obtained from the United States (where these diseases are of great importance) and several of these have proved to be highly

resistant to our strains of *Fusaria* and also satisfactory from the market point of view.

A large number of seedling hops have been worked up for experiments in the transmission of virus diseases.

Papers were published on the biology and control of the basket willow rust *Melampsora Amygdalinæ* (9, 10). Further trials have been carried out in 1933, but with inconclusive results, since 1933 was not a "rust year."

Other willow rusts have been under investigation, especially that on the Cricket bat willow and that on *Salix daphnoides*.

A prevalent and destructive canker of cricket bat willows is being investigated.

Titles of papers issued during the year.

1. Ogilvie, L.: Investigations on vegetable diseases in the Bristol Province. *Hort. Educ. Assn. Yr. Bk.*, **1**, 1932.
2. Ogilvie, L., and Mulligan, B. O.: Vegetable diseases in Worcestershire. I. "Halo Blight" of dwarf beans. *Worcs. Agric. Chron.*, **1**, 2, Feb. 15th, 1933.
3. ————: II. "White tip" disease of leeks. *Ibid.*, **1**, 3, May 15th 1933.
4. ————: III. Leaf and pod spots and foot rots of peas. *Ibid.*, **1**, 4, August 15th, 1933.
5. Ogilvie, L.: Downy mildew of hops. *Hereford. Agric. Quart. J.*, **1**, 2, June, 1933.
6. ————: The control of hard rot of strawberry fruits. *Ann. Rep. Long Ashton Res. Sta.*, 102, 1932.
7. Ogilvie, L., and Mulligan, B. O.: Progress report on vegetable diseases, IV. *Ibid.*, 103-120, 1932.
8. Ogilvie, L.: Ring spot and spotted wilt of tomatoes and ornamental plants. *Ibid.*, 121-122, 1932.
9. Ogilvie, L., and Hutchinson, H. P.: *Melampsora Amygdalinea*, the rust of basket willows (*Salix triandra*). I. Observations and Experiments in 1932. *Ibid.*, 123-130, 1932.
10. Ogilvie, L.: *Melampsora Amygdalinea*, the rust of basket willows (*Salix triandra*). II. Spore germination experiments. *Ibid.*, 131-138, 1932.
11. ————: Canker and die-back of apples associated with *Valsa ambiens*. *J. Pom. and Hort. Sci.*, **11**, 3, 205-213, Sept. 1933.
12. Mulligan, B. O.: Asparagus. *Gard. Chron.*, **93**, 65, Jan. 28, 1933.

77. CAMBRIDGE UNIVERSITY

Helminthosporium diseases of oats and barley.—These investigations have been continued. The toxicity of mercuric salts, with which satisfactory control was obtained, is under investigation. Further work on the "dusting" treatment for seed grain has been carried out (1).

Action of light on disease organisms.—It was found that abundant sporulation of *Helminthosporium avenae* can be induced by irradiating cultures with the light from a quartz mercury-vapour sun lamp, or by submitting non-sporing cultures, out-of-doors, to either strong diffuse light or sunlight.

" *Chalkiness* " *in tulips.*—Experimental work on " chalkiness in tulips " has been carried out and is being continued. It was observed that riddled bulbs show more signs of " chalkiness " than hand-graded bulbs, from which it would appear that this condition is mainly due to bruising.

" Fire " in tulips has also been investigated.

Sugar beet diseases.—In a recent survey of the diseases of sugar beet the " blackleg " condition of the seedling was found to be prevalent, and the chief causes for this were ascribed to lack of lime, poor drainage conditions and *Phoma Betae*. It is thought likely, however, from some experimental work that has been carried out, that *Pythium de Baryarum* may also be a factor. From the commercial point of view, however, these troubles can be circumvented by sowing dressed seed on well drained and sweet land.

Leaf scorch (*Sporidesmium putrefaciens*) also has been very prevalent, and this, together with the drought, has been responsible for the scorched appearance of the foliage.

Violet root rot (*Helicobasidium purpureum*) is still prevalent, and it is suggested strongly that sugar beet should not be taken in successive seasons on land that is known to be contaminated.

Other investigations carried out during the year were as follows :—

(i) A survey of the prevalence of asparagus rust (*Puccinia Asparagi*).

(ii) A " target-like " leaf spot on potato foliage.

(iii) Work on spore discharge from the fructifications of *Stereum purpureum* after spraying.

Titles of papers issued during the year.

1. Dillon Weston, W. A. R.: Seed treatment. *Husbandry*, **3**, 1, 1933.
2. ————: Dressing spring corn. *Field*, 161, 431, 1933.

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78. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES

Sainfoin.—Observations on some of the commercial strains are being concluded and a few plants have been selected for vegetative propagation. With regard to local strains, the work is developing on the study of cuttings from different plants in comparison with seed saving. Vegetative propagation shows for instance that mildew is more severe on the progeny of some plants than others. The plants from the seeds of the same mother-plant show some variation in their susceptibility to mildew and leaf spot as well as in habits of growth owing to crossing with pollen from different plants. So far it has not been possible to obtain much seed by " bagging " flowers.

Lucerne.—Observations on the persistence, hardiness, and diseases of the 23 lots of lucerne have continued. Four new lots have been added.

Grasses and clovers.—The pedigree strains of cocksfoot and timothy from Aberystwyth have been compared with commercial strains. Further a large number of special commercial strains of ryegrasses, cocksfoot and timothy, were sown, but owing to that part of the Green Farm plot being taken from the College these plots had to be sacrificed. The creeping and chewing strains of red fescue and the various strains of bent sown this spring, are proving interesting. Plots of some special strains of English, Welsh, and foreign broad and late flowering red clovers have been started as well as of white clovers and miscellaneous leguminous forage plants.

Soya bean.—This experiment was extended to include more lots of seed which now appear to be the same strains as the original black and brown. Some preliminary manurial tests which indicate the value of added nitrogen and particularly organic matter such as lawn cuttings have been carried out.

Manurtng of lawns.—The small plots at the Green Farm have been continued but some have been modified by dressing with " lawn sand " at varied intervals. The summer drought masked to a large extent the effect of the manures.

Yellow and brown rusts of wheat.—Five varieties of wheat have been grown for observation on the above rusts which are studied further at Cambridge. The variety Wilhelmina was not included this year but as a result of last year's work it was found at Cambridge that the form of yellow rust attacking this variety at the Green Farm was distinct from those found elsewhere. Wilhelmina is frequently grown in this district and often suffers severely from yellow rust. The incidence of the rusts was very slight on the varieties grown in 1933, the yellow rust being slighter than the brown rust and both later in appearing than in 1932.

Seed pickling.—Different proprietary organic mercury compounds have been tested for the treatment of the seed of oats and barley both at the Green Farm and at farms in Glamorgan. These compounds appeared effective under certain conditions of seed infection. The result with barley leaf stripe was very effective, and also with oat leaf spot. The germination of dressed seed was good, but owing to smut being almost absent, it was not possible to estimate their value in controlling this disease under our conditions. The " leaf " diseases of barley and oats were checked in the early period but seed treatment did not prevent wind-borne spores spreading the diseases later.

Finger-and-toe.—Trials with resistant varieties of swedes and turnips have been made at three centres where the disease is known in Monmouthshire. This year a Swedish variety of swede was included as well as some English selections but there has been no apparent improvement on the Wilhelmsburger.

The corrosive sublimate treatment against clubroot has been tried at one Glamorgan market garden with cauliflower and appears to have given better growth.

Grassland.—Botanical analysis of plots manured for hay at Usk has been carried out in the laboratory.

Titles of papers issued during the year.

1. Rees, J.: The effect of milling on sainfoin seed. *Welsh J. Agric.*, **9**, 170-175, 1933.
2. ————: Crop diseases in South Wales. Their causes. Suggested methods of control. *Western Mail Agric. Sup.*, March 6, 1933.

79. HARPER ADAMS AGRICULTURAL COLLEGE

Control of finger-and-toe disease.—Co-operative trials with mercuric chloride were carried out in co-operation with five other Provinces. The consistent results obtained confirmed the value of the treatment previously advocated. Used when transplanting, a 0·05 per cent. solution of mercuric chloride increased the marketable heads by an average of 50·8 per cent., an 80 per cent. increase being attained on some plots. Applied to the seed-bed the solution proved less satisfactory and the results were conflicting. Further co-operative work has been arranged.

Excellent control of finger-and-toe was again obtained with a 0·05 per cent. aqueous suspension of mercuric oxide. It appears to be quite as effective as mercuric chloride.

Claim had been made that sawdust impregnated with creosote would control finger-and-toe. Controlled experiments over two years proved this mixture to be quite ineffective.

Control of michaelmas daisy wilt.—It has been successfully demonstrated that plants quite free from the fungus *Verticillium Vilmorinii* can be obtained from infected stocks by taking " top-cuttings " and rooting them in sterilised soil.

Comparison of Welsh and Scotch potato stocks.—Tests with four varieties of Welsh-raised, virus-free potato stocks were again made in cooperation with University College, Bangor. The figures obtained were quite favourable to the Welsh stocks, which appeared easily to hold their own with the Scotch-raised seed.

Rusts on wheat.—Observations on the incidence of certain " rust " diseases were made on specially sown plots in cooperation with Cambridge University. Seed of five wheat varieties was supplied, and records of the prevalence of *Puccinia glumarum* and *P. triticina* upon the plants raised were made at regular intervals.

Title of paper issued during the year.

Preston, N. C.: Finger-and-toe disease (Club root) and its control. *Staffs. Fedn. of Allot. Holders Yr. Bk.*, 1932.

80. LEEDS UNIVERSITY

Anthracnose disease of begonia.—This disease has now been fully worked out and an account is being prepared for publication. The cause of the disease is found to be a species of Colletotrichum hitherto undescribed.

Stem rot of cauliflower (Phoma lingam).—Trials were made of seed disinfection by different methods but owing probably to the dry season the disease was not reproduced on the seedlings either in the control or treated seed beds and the experiment was therefore valueless.

" Whiteheads " in wheat.—A field experiment covering half an acre has been laid down in a field at Wetwang on the Wolds where, as reported, a 100 per cent. loss occurred last season. The following soil treatments have been applied :—sulphate of iron, formaldehyde, green manure, farmyard manure, potash and artificials. Further experiments to test the susceptibility of other host plants are also in progress.

Verticilliosis (?) of field beans.—In a total failure of this crop where a desiccation of the roots and stems occurred, it was found that the roots showed a heavy infection of a *Verticillium sp.* The fungus has been isolated and inoculation experiments are in progress.

Celery leaf spot.—Spraying trials with a proprietary colloidal copper compound were laid down at Hemingbrough. Owing, however, to the lightness of infection on the control plots the results were not very instructive. There is no doubt that spraying would become much more general if some ready made substitute for Bordeaux mixture could be found.

Title of paper issued during the year.

Burr, S.: Lightning damage to potatoes. *Gard. Chron.*, **94**, 2429, 48, 1933.

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81. MANCHESTER UNIVERSITY

Celery blight (Septoria Apii).—By following up the formaldehyde treatment of the seed and soil with regular weekly sprayings of a copper fungicide, seed bearing plants have been raised absolutely free from this destructive disease (1). Samples of the seed, when tested at the Official Seed-testing Station, Cambridge, this year, showed 100 per cent. clean seed.

Clubroot of brassicae (Plasmodiophora Brassicae).—A dry dressing, for the control of both clubroot and maggot of brassicae, has been devised and has proved most effective and suitable in market-gardens and allotments. The treatment is intended to

supplement the liquid dressings applied in the seed-bed. Tests of a so-called "resistant" variety of yellow turnip have also been made at three centres, but will need to be repeated in 1934 before reliable and fair comment can be made.

Blackleg of brassicae (*Phoma Lingam*).—Infected seed, dressed against this disease, was sown down at four centres, but the persistent dry weather interfered with the reliability of the observations in the field. The experiments will therefore be repeated in 1934.

Tomato mildew (*Cladosporium fulvum*); *Cucumber mildew* (*Erysiphe Cichoracearum*); *Chrysanthemum mildew* (*Oidium Chrysanthemi*).—A single solution salicylanilide spray has now been tried out experimentally on a commercial scale at a number of nurseries. If used at $\frac{1}{4}$ per cent. strength in the early stages and repeated on at least two occasions at weekly intervals, this spray will effectually control the above diseases at quite moderate cost. In each case ventilation of the houses must be adequate.

Apple mildew (*Podosphaera leucotricha*).—The direct application of potash to the soil coupled with regular routine sprayings with lime-sulphur has gradually reduced the incidence of this disease at one large commercial nursery till it is almost insignificant in amount.

Lettuce canker (*Botrytis cinerea*).—Faulty manuring, particularly an excess of inorganic nitrogen in the early stages of growth, has been shown by a series of manurial experiments to favour this disease. On the other hand, organic nitrogen and residual manures from a previous tomato crop plus a light dressing of potash encourage healthy growth. No overhead watering and the preservation of a surface mulch discourages infection.

Grey leafspot of oats.—This physiological trouble has been shown to follow excessive liming, especially on peat soils. Various chemical dressings to correct the unbalanced soil constituents are being tried out. Manganese sulphate and slag (containing a definite percentage of manganese) have both given very promising results at one centre.

Titles of papers issued during the year.

1. Smith, E. Holmes.: Celery blight control. *Gard. Chron.*, **93**, 185 and 193-194, 1933.
2. ————: Spotted wilt of tomatoes. *Ibid.*, **94**, 350-351, 1934.

82. MIDLAND AGRICULTURAL COLLEGE

Prevention of celery blight (*Septoria apii*) *by seed treatment.*—The best results of treating celery seed infected with *S.apii* have been obtained by soaking the seed for periods up to 24 hours in

40 per cent. formalin, 1 in 300; this treatment, however, is only partially successful in preventing leaf-spot. Experiments have now been carried out with a double treatment of the seed, viz., formalin, 1 in 300, followed by dusting with a dry organic mercury compound. Where the seed was untreated, there was 100 per cent. infection. Formalin alone gave good results, but there was slight infection of a few seedlings. About 50 per cent. of the plants were infected when the dry powder alone was used. The double treatment of seed gave the best results; there was no sign of infection on any of the plants, but the germination capacity of the seed was seriously reduced.

Sleepy disease (Verticillium albo-atrum) of tomatoes.—Experiments have been carried out on a commercial scale in a number of greenhouses on the prevention of sleepy disease of tomatoes. The results showed that the treatment of infected soil with 2 per cent. formalin, using about seven gallons per square yard, exercised a very good control of the disease. In addition, it improved the growth of the plants and the subsequent crops. In the untreated house the crop was 50 per cent. less than in the previous year, whereas in the house treated with formalin the crop was 50 per cent. better than in the year before.

" Spotted wilt " of tomatoes.—Inoculation experiments have been carried out using different methods to find out the easiest and quickest way of diagnosing this disease in suspected tomato plants. The best results were obtained by slightly bruising the leaves from an infected plant in a mortar and inoculating by gently wiping the juice obtained on to the leaves of healthy tomato and petunia plants.

" Ringy disease " or " watermark " in carrots.—A serious disease of carrots, hitherto undescribed, exists in certain carrot fields in North Nottinghamshire. The disease causes depressed, discoloured rings around the roots. It appears to be caused by a phycomycetous fungus and is probably soil-borne. Carrots infected by this fungus are often attacked by a secondary bacterial rot. The rot spreads to healthy carrots when they are stored in " hills " throughout the winter. Work is proceeding on this disease.

Lawn treatment.—Experiments have been carried out against attacks of the fungus *Corticium fuciforme* on lawns, golf greens and fairways. Weak permanganate of potash and mercuric chloride, 1 in 2,000, have given promising results.

83. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY

Blight (white tip) of leeks (Phytophthora porri).—Perfect control was obtained by suitable applications and strength of Bordeaux mixture. The treatment has been reduced to simple inexpensive form which meets the needs of the hundreds of small growers interested in leek growing.

Fusarium species on British cereals.—Fusaria tricinctum, sambucinum, herbarum var. gibberellioides.—These species have been studied from a diagnostic point of view. The results are awaiting preparation for publication, and should be useful in helping to distinguish between pathogenic and non-pathogenic species of Fusarium common on cereals.

Fusarium patch disease of bowling and putting greens (3).—The causal fungus *F. nivale*, was studied in detail as isolated from cereals in Britain (1). The organism was later found to be the cause of a disease in the turf of bowling and putting greens, and was isolated from turf specimens submitted from districts ranging from Surrey to Aberdeen and North Ireland. Pathogenicity of the fungus was proved by pot experiments. In the investigation directed towards remedial measures by cultural work, it was discovered that the aniline dye, malachite green, was exceedingly toxic to the fungus. This material was tried out in the pot experiments and was so successful that it was applied to outdoor trials. Treatment of a badly diseased bowling green gave proof that this material, applied in a certain way, nearly eliminated the disease under even most difficult conditions. Other greens under treatment are equally satisfactory.

Titles of papers issued during the year.

1. Bennett, F. T.: Fusarium species on British cereals. V. *F. nivale* (Fr.) Ces. *Ann. Appl. Biol.*, **20**, 272-290, 1933.
2. ————: Fusarium species on British cereals. VI. *F. graminearum* Schw.—*Gibberella Saubinettii* (Mont.) Sacc., III. Natural occurrence of perithecial stage. *Ibid.*, **20**, 377-380, 1933.
3. ————: Fusarium patch disease of bowling and golf greens. *J. Bd. Greenkeeping Res.*, **3**, 79-86, 1933.

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84. READING UNIVERSITY

Canker and dry rot diseases of swedes.—This investigation has been brought to a close, and the results obtained on these diseases caused by the fungus *Phoma Lingam* have been written up for publication.

Phytophthora diseases of tulips.—Further information about the mode of parasitism, and methods of control, of the diseases of tulips caused by *Phytophthora erythroseptica* and by *P. cryptogea*, of which one phase is referred to as " Shanking " by the practical grower, has been obtained. It is expected that the experiments in progress during the winter of 1933-34 will round off the investigation.

Clitocybe dealbata as an invader of mushroom beds.—Serious cases of this trouble were found in Hampshire, and a short article was written in collaboration with Mr. W. M. Ware of the South Eastern Agricultural College (1).

Title of paper issued during the year.

Buddin, W., and Ware, W. M.: *Clitocybe dealbata* as an invader of mushroom beds. *Gard. Chron.*, **93**, 246-249, 1933.

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85. SEALE-HAYNE AGRICULTURAL COLLEGE

Finger-and-toe field trials.—Excellent control was obtained by quick lime and hydrate of lime at two centres. Cases of failure from liming have been investigated and shown to be due either to inadequate dressings or the use of lime in an inactive form.

Diseases of narcissi, tulips and iris.—The experiments and observations mentioned in previous reports have been continued and accounts of the work are in preparation. The use of sprays has not met with much success so far and new materials are being tried. The results of a co-operative trial on root-plate rot in daffodils are being collected.

Anemone failures.—As reported last year much loss is suffered in the winter months, and observations have shown the problem to be largely one of soil fertility. A potash dressing trial has been laid down at the College, and cases elsewhere have been investigated and the soils analysed.

Potato blight.—An account of the work on the times of planting in relation to the disease has been prepared. Detailed observations and their bearing on present-day conceptions of disease and susceptibility have been continued. Detailed observations were again made of the weather in relation to the epidemic and the practicability of spray warnings demonstrated.

Titles of papers issued during the year.

1. Beaumont, A., and Staniland, L. N.: Ninth Annual Report, Department of Plant Pathology. *Seale-Hayne College Pamph.*, 40, 1933.
2. Beaumont, A.: Symposium and discussion on the measurement of disease intensity. I. Potato blight. *Trans. Brit. Mycol. Soc.*, **18**, 174-178, 1933.

86. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY

Downy mildew of the hop (*Pseudoperonospora humuli*).—Experiments were carried out in which a copper-lime powder was applied to the hills just before and during the period of production of basal spikes. No definite effect on the suppression of basal spikes was observed.

Virus diseases of the hop.—Chlorotic disease.—A case of the natural spread of this disease (the first recorded) was observed at Wye. Seed sown from fuggle plants affected with this chlorosis has given evidence that this disease can be transmitted by seed. A third paper in the series has been published (2) giving the results of further grafting and budding experiments.

Apple scab.—Spraying experiments have been continued for the seventh year, in the College plantation at Wye. Similar plots of Allington and Newton have been sprayed, respectively, with home-made bordeaux mixture and a home-made vegetable oil-bordeaux emulsion. The crop was graded by hand for the amount of scab present. The results of the spraying experiments at Wye in 1932 have been published (7). A spraying demonstration was again carried out in an apple orchard at West Farleigh, near Maidstone. Biological observations respecting the incidence of scab were kept through the season. A satisfactory control was obtained at small cost by four sprayings with either lime-sulphur or bordeaux mixture.

Pear scab.—A spraying experiment against this disease was carried out on a farm near Graveney, Kent. Randomised plots of four varieties were sprayed either with bordeaux mixture or with cotton seed oil-bordeaux emulsion. A very good control of scab by both of the spray fluids was obtained. Three post-blossom applications gave better control than two.

Experiments with fungicides.—Biologically-controlled experiments with the hop powdery mildew (*Sphaerotheca humuli*) have been carried out with various copper-containing sprays, certain organic sulphur compounds and substances suitable for use as spray spreaders. The investigations of the fungicidal properties of vegetable oils have been completed, and an account published (5).

Fungus invaders of mushroom beds.—In co-operation with the Economic Mycologist, Reading University, an occurrence of the fungus *Clitocybe dealbata* in mushroom-beds in Hampshire was investigated. In the present instance it is concluded (4) that it was introduced with the stable-manure used for the beds. Three cases of invasion of mushroom-beds by mycelium and sclerotia of a fungus, generally assumed to be *Xylaria vaporaria*, were investigated. In each instance the fungus was induced under artificial conditions to produce the perfect (*ascus*) stage and it was then found that it did not agree in all respects with descriptions of *X. vaporaria*. The investigations are being continued.

Titles of papers issued during the year.

1. Ware, W. M.: High temperature injury on the growing apple. *Gard. Chron.*, **92**, 287-288, 1932.
2. Salmon, E. S., and Ware, W. M.: The chlorotic disease of the hop, III. *Ann. Appl. Biol.*, **19**, 518-528, 1932.
3. Goodwin, W., and Ware, W. M.: Mushroom growing. (Review.) *Gard. Chron.*, **92**, 451-452, 1932.
4. Buddin, W., and Ware, W. M.: *Clitocybe dealbata* as an invader of mushroom beds. *Ibid.*, **93**, 246-248, 1933.
5. Martin, H., and Salmon, E. S.: The fungicidal properties of certain spray fluids, X. Glyceride oils. *J. Agric. Sci.*, **23**, 228-251, 1933.
6. Salmon, E. S., and Goodwin, W.: Modern practice in the control of the hop downy mildew in the Hallertau (Review). *Brewers' J.*, **69**, 399-400, 1933.
7. Goodwin, W., Martin, H., Salmon, E. S., and Ware W. M.: The control of apple scab: Allington Pippin and Newton Wonder, 1932. *J. S.E. Agric. Coll.*, 32, 95-107, 1933.
8. Salmon, E. S., and Ware, W. M.: The downy mildew of the hop in 1932. *Ibid*, 108-119, 1933.

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87. ABERDEEN: NORTH OF SCOTLAND COLLEGE OF AGRICULTURE

British grasses.—It is noteworthy that less than 10 per cent. of our native grasses play any role in agriculture or in the constitution of the swards of sports grounds. It is not improbable that many of those as yet unutilised may be capable of exploitation. For example the discovery of a grass which would colonise peat would be of great value. A careful study of British grasses is being made both from the economic and systematic point of view. The need for an accurate means of determination of grasses during the greater part of the year, when flowers are not available, has lead to a comprehensive examination of British grasses in this state and the results will be published in the near future.

It is a matter of common experience, both with agricultural and horticultural seeds that the soil germination (establishment) is considerably less than might be expected from figures obtained under laboratory conditions. An inquiry has been proceeding, for the past few seasons, into the factors operating against fuller germination in the soil, including the action of parasites. The effect of fungicidal treatment of seeds is being noted.

Weed control.—The investigation into the efficacy of chlorates in weed control has been completed. A detailed account of the experiments has been published with recommendations based upon the experiments (1) (2). A solution of sodium chlorate was found more effective in this area than dry applications. For perennial weeds, autumn dressings are advocated and the desirability of turning over the soil by ploughing prior to application of the chlorate is emphasised. Chlorates are removed from the soil

partly by decomposition, partly by leaching. Depressing effects of the chemical on the subsequent crop are apt to follow late application especially in the case of deep rooting plants, viz., turnips. There are certain but *avoidable* risks run in using this chemical. Prospective users should acquaint themselves with these before using chlorates.

Titles of papers issued during the year.

1. Clouston, D., and Hill, A.: The use of chlorates as weed eradicators. *Scott. J. Agric.*, **16**, 2, April, 1933.
2. ————: The use of chlorates in weed control. *Trans. Highland and Agric. Soc. of Scotland*, **45**, 1933.

88. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE

Hill pasture investigations.—The investigations on the hill pasture attached to the College Farm, Boghall, were continued, and new experiments were initiated with a view to attempting the improvement of some types of vegetation which have hitherto not proved responsive to manurial treatment. Mechanical treatment by various tractor-drawn machines was resorted to with a view to the destruction of the dense sod which is characteristic of much of the hill land, and this was followed by the application of manures and the sowing of seeds, cleanings from commercial grass and clover seeds being employed for the purpose.

A paper was published in collaboration with Dr. W. G. Ogg of the Macaulay Institute for Soil Research dealing with the earlier experiments carried out on the hill pasture (1).

Seeds mixture experiments.—A number of additional seeds mixture trials was laid down at various centres in the College area in co-operation with the county staff. These are in the main designed for the field trial of new products from the Scottish Plant Breeding station.

Pasture survey.—A survey of the pastures of part of a parish in Berwickshire was carried out during the summer. The rapid deterioration of sown pastures in this area is a serious problem and an earlier soil survey of the parish had suggested that soil conditions probably played a large part in determining the rate of deterioration. A field to field survey was therefore undertaken, notes being made upon the botanical condition of the sward, survival of sown species, invasion by unsown species, etc., while soil samples were taken for analysis. This investigation is being carried out in collaboration with the Macaulay Institute, where the soil analysis will be done.

Weed spraying trials.—The success previously obtained with sodium chlorate as a spray against weeds in Italian rye grass led

to trials being undertaken to test its value as a spray against charlock and runch in cereal crops. Trials were conducted on small plots at a number of centres, spraying being carried out by means of a knapsack sprayer. Copper sulphate was included in the trials for comparative purposes. The results showed that a 1 per cent. solution of sodium chlorate is effective in destroying charlock, but that runch, though checked, is not destroyed by the treatment, although it can be completely killed by a 10 per cent. solution of sulphuric acid. A 1 per cent. solution of sodium chlorate was found to be about as effective as a 5 per cent. solution of copper sulphate in destroying the weeds. At some of the centres, however, it was noticed that the sodium chlorate treatment resulted in a more or less severe check to the cereal. This did not appear until a few days after spraying and took the form of a general yellowing and dying back of the leaves from the tips, the lower leaves being most severely affected. It is thought that this effect is not due to the direct scorching effect of the chlorate on the foliage but to its being washed down into the soil and damaging the surface roots with consequent damage to the leaves. In view of this fact, the use of sodium chlorate as a spray against annual weeds in cornfields cannot be recommended.

Grassland research.—Work on grassland research, with particular reference to its ecological aspect, has been continued. Recently, the relationship of certain grasslands to the " Oakwood Association " was established for certain parts of Devon, the importance of the grazing animal being noted (2). The problems connected with sectional grazing and manuring of grassland were summarised in an article in the Scottish Journal of Agriculture (3). The changes in the natural flora and vegetation of Scotland were discussed in a paper read to the Agricultural Education Association (4), and two papers on " Methods of pasture analysis " were communicated to the Association's Journal (5).

Fungus on turnips.—An investigation of the pathogenicity and life-history of a fungus (*Typhula sp.*) found on turnips during January, 1932, has been carried out. Danish investigators have reported this fungus as causing considerable damage. The work so far suggests that in this country the fungus only grows on dying or dead turnip plants on which it forms its resting sclerotia.

Titles of papers issued during the year.

1. Heddle, R. G., and Ogg, W. G.: Experiments in the improvement of hill pasture. *Scott. J. Agric.*, **16**, October, 1933.
2. Fenton, E. Wyllie: The influence of grazing on vegetation. II. The removal of the grazing factor. *Trans. Proc. Torquay Nat. Hist. Soc.*, 1931-32.
3. ————: Sectional grazing and manuring of grassland. *Scott. J. Agric.*, **15**, 4, 1932.
4. ————: The vegetation of Scotland past and present. *Agric. Prog.*, **10**, 1932.
5. ————: Methods of pasture analysis: IV. The percentage area method; V. The point quadrat method. *Ibid.*, **10**, 1932.

89. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE

Leaf stripe disease of oats.—A large number of potential seed disinfectants were tested at Auchincruive against leaf stripe disease of oats during the session 1932-33. These experiments confirm previous experience in showing that organic mercury preparations are much superior to inorganic mercury compounds and to all similar organic compounds of various other metals dealt with. It is intended to carry out more extensive tests with certain promising compounds during 1933-34. It is estimated that in 1933, 600,000 acres of oats were grown in Scotland from disinfected seed. A monograph on this disease was published during the year (1).

Manganese deficiency in oats.—This disease is widespread in the West of Scotland, but it is difficult to arrive at a reliable estimate of the losses caused thereby. Previous investigators have arrived at conflicting conclusions regarding the factors which contribute to the development of manganese deficiency in the plant. A large number of pot experiments have been laid down at Auchincruive with a view to obtaining information on this point.

Crown rust of oats.—Crown rust (*Puccinia coronata*) was extremely abundant on all varieties of oats grown in the experimental field during the summer of 1933. As a rule this disease is seldom noticeable in the College area, probably owing to the prevailing climatic conditions being unfavourable for its development. It is noteworthy that no species of Rhamnus is native to the south-west of Scotland and experiments are being carried out with a view to determining the source of the Uredo stage in oats.

Rusts were also developed on perennial ryegrass (probably a form of *P. coronata*) and cocksfoot (*Uromyces Dactylidis*) to an alarming extent. Scarcely a leaf of any of these grasses could be found in an uninjured condition. *P. graminis* was recorded on one strain of perennial ryegrass.

Eelworm disease of potatoes.—This disease is extremely prevalent on the Ayrshire coast, where early potatoes have been grown continuously for, in some cases, over 70 years. So far the only practicable means of control has been the adoption of a rotation in which potatoes recur only once in five years. Control of *Rhizoctonia solani*, almost invariably associated with eelworm on potatoes, by disinfecting the setts with a solution of Semesan prior to planting resulted in no significant increase in yield. This would seem to indicate that the fungus has little or no effect in causing potato sickness, which is attributable solely to *Heterodera Schachtii*.

Titles of papers issued during the year.

1. The helminthosporium disease of oats. *West of Scot. Agric. Coll Res. Bull.* 3, February, 1933.
2. Dennis, R. W. G.: Studies in the morphology and biology of *Helminthosporium Avenae*. *Trans. Brit. Mycol. Soc.*, **18**, 3, 223-238, Dec., 1933.

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VETERINARY SCIENCE

90. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES

Braxy.—It has been shown that true braxy is the cause of the sudden deaths among young sheep in North Wales which occur in late autumn and early winter. Anaculture prepared against *Vibrion septique* has been used in extensive field trials, and this single dose vaccine has given most satisfactory results.

" Wool-ball " in young lambs.—The so-called " wool-ball " deaths in young lambs have been under observation for a number of years, and it has been shown that the intestinal contents of these lambs contain a very potent toxic element now identified as a *B. Welchii* toxin of the ovitoxious type. Examination of intestinal contents cultures, so far as they have gone, suggests that this type of *B. Welchii* will be isolated therefrom with regularity. It would seem, then, that this disease is identical with the " pulpy kidney disease " investigated by Gill in New Zealand and by Oxer in Tasmania. The preparation of an antiserum is in hand.

" Strike " in ewes.—This disease commonly causes a number of deaths in spring in lowland flocks in North Wales, but its incidence is very variable. Although the number of good cases investigated is small, it would seem that in this case also the intestinal contents regularly contain a toxin of the ovitoxious type in high concentration and a vast number of bacteria of the *B. Welchii* group. This disease is an infectious entero-toxaemia quite comparable with the condition investigated by Bennetts in Western Australia.

Contagious abortion.—Observations on the application of the segregation method of control have been continued. The disease appears to have been successfully controlled and even eradicated in some of the herds.

Trials of the effects of live vaccination of maiden heifers have been commenced. In the observation of longest standing it appeared that the vaccinated animals overcame infection before service (a period of three months).

Contagious pustular dermatitis.—With the co-operation of the Institute of Animal Pathology, Cambridge, a trial of vaccination of very young lambs as a means of preventing the early appearance of this disease annually in one flock was carried out. The vaccination did not appear materially to influence the incidence of infection or the course of the disease in these young lambs.

The virus showed a tendency to spread from the site of vaccination (inside the thigh of a hind leg) to the lips.

Lamb dysentery.—In past years excellent results have been obtained from the use of serum in the control of lamb dysentery, but during the past spring this serum has failed to maintain its reputation on certain farms. This led to a further investigation of lamb dysentery, and it has been shown that in this case also the disease is essentially an infectious entero-toxaemia; the toxin in the intestinal contents being either of the type produced by *B. ovitoxious* or of the type produced by *B. paludis*. It has further been shown that recently isolated strains of the lamb dysentery bacillus produce a particularly complex toxin which includes both of these types, whereas a long isolated, well established strain produced a more simple toxin with no fraction of the ovitoxious type. This work has demonstrated the necessity for lamb dysentery serum containing anti-toxin against the toxin of B. *ovitoxious*, explained the failures already experienced and pointed the way to avoid the very harmful consequences further serum failures would have.

Titles of papers issued during the year.

1. Rowlands, W. T.: The incidence of *B. tuberculosis* and *Br. abortus* in the herd milks supplied to a small city. *Vet. Rec.*, **13** (N.S.), 7, 127-128, 1933.
2. Montgomerie, R. F., and Dalling, T.: The identification of **B. ovitoxicus** type of toxin from the intestine of sheep in Great Britain. *Vet. J.*, **89**, 5, 223, 1933.
3. Montgomerie, R. F., and Rowlands, W. T.: Pulpy kidney disease of young lambs in North Wales. The toxicity of intestinal contents and the nature of the toxic element. *Ibid.*, **89**, 9, 388-398, 1933.

91. BRISTOL UNIVERSITY

An investigation into the problem of " teart " land in Somerset was commenced in October, 1932. It was hoped to proceed with feeding experiments on this year's aftermath, but the drought rendered such trial impossible. Next year every opportunity will be taken in an attempt to elucidate this problem.

Lamb dysentery caused serious losses during the last spring, the disease being much more widespread than in previous years. The use of anti-serum has given excellent results on most farms. Outbreaks where the disease had reached an acute form were met with, the farmers in these cases using the " powder " treatment with very poor results.

Trials with Johnin have been continued.

Parasitic gastritis and enteritis in lambs have been encountered on several occasions, the worms present in two outbreaks being of the Ostertagia species. Dosage with nicotine sulphate solution

was tried in these cases with quite good results as far as could be judged from cessation of fatalities and improvement in condition. Unfortunately, it was not convenient to have controls but it is hoped to make further observations on the efficacy of this drug.

Titles of papers issued during the year.

1. Menzies, D. W.: Some common diseases of the fowl. *Wilts. Assoc. Dairy Students' J.*, Oct., 1932.
2. ————: Liver rot of sheep. *Somerset N.F.U. Rec.* **1**, 11, Nov., 1932, and *Worcs. Chron.*, **1**, 1, Jan., 1933.
3. ————: Some common sheep ailments. *Glos. Farmer*, **1**, 2, Feb., 1933, and *Hereford J.*, **1**, 2, June, 1933.
4. ————: Enteritis in poultry. *Worcs. Chron.*, **1**, 2, Feb., 1933.
5. ————: Mastitis or garget of dairy cows. *Ibid.*, **1**, 3, May, 1933.

92. CAMBRIDGE UNIVERSITY

Lactation tetany of Cattle.—The investigation commenced last year was continued. The disease was not so prevalent in many districts, but fortunately it was possible to investigate a number of cases in an area where the disease recurs annually. Details of the observations made on the disease, as it occurs in four districts, will be published in the near future.

Johne's disease.—While this disease is by no means as prevalent in the Eastern Counties as in the more intensive dairying districts, its occurrence does cause considerable losses on some farms. Several of the Johnins sold for the diagnosis of the disease have been used on selected herds and their values compared. These trials suggest that while Johnin is by no means infallible as a diagnostic agent, its use together with other measures is of considerable value in the eradication of the disease from affected farms.

Abortion in pigs.—Abortion in pigs does not appear to be common, but two outbreaks have been encountered and investigated. In neither case was there evidence that the condition resulted from infection with *B. abortus* (Bang) or any other specific organism.

Fowl cholera.—During the early summer serious outbreaks of disease amongst ducks in Norfolk were reported to the adviser. An investigation revealed that the losses were due to fowl cholera and that a considerable number of farms in the duck fattening area of the county were affected. The outbreak caused considerable loss to the industry and resulted in the death of many thousands of birds.

Fowl paralysis.—A survey of the prevalence of this disease is being made in collaboration with the county poultry instructors

and the material provided by this scheme is being used for investigational work into the causation of the disease.

Fowl typhoid.—No fresh outbreaks of this disease have occurred during the year, but one experiment has been conducted on a farm known to be heavily infected. Vaccination of a portion of the flock was carried out after the elimination of birds proved to be " carriers " by the agglutination test. This procedure did not prevent the recurrence of the disease and from this and previous experiences it is considered that vaccines are of doubtful prophylactic value.

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93. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES

Sheep diseases.

Parasitic gastritis.—This condition has been comparatively widespread, as it was last year. In the majority of cases treatment with copper sulphate was successful, but in several instances flocks did not respond. In some of these it was found that owners were not thoroughly carrying out the conditions laid down by the department. In others, however, investigation showed that the predominant worm present was *Ostertagia* and not *Haemonchus*. Several methods of treatment are being tried experimentally with a view to combating *Ostertagia*. It is too early to estimate the results, but the most promising at present seems to be a new arsenical preparation.

" *Swayback.*"—Investigations are still proceeding into this condition. There are now some grounds for suspecting that the condition is related to mineral or vitamin deficiency on the part of the ewe, and investigations are now proceeding along these lines.

Poultry diseases.

Coccidiosis.—The incidence of coccidiosis has not increased to the same extent as it did last year. A number of cases in adult stock which showed symptoms of blindness and leg weakness, and were suspected of being affected with so-called fowl paralysis, responded to treatment with iodised milk and epsom salts. Last year all attempts at treatment of the condition in adult stock were unsuccessful. It is proposed to test a new method of treatment for which success is claimed in France, and arrangements are being made for this purpose.

Infectious entero-hepatitis (" *Blackhead* ").—Preventive inoculation with Neo-salvarsan was carried out on a flock of turkeys on premises where " blackhead " had been a serious source of loss. The results were so satisfactory that the owner is desirous of having

the inoculation repeated this season. Experiments are being conducted with another preparation of a similar nature. Although some authorities do not recommend treatment of affected turkeys, there is no doubt that dosage with liquid extract of ipecacuanha, has given effective results when thoroughly carried out.

Cattle diseases.

Summer mastitis.—An outbreak of this disease caused severe losses on a certain farm on which it had been endemic for a considerable number of years, and on which last summer, practically every cow was affected. On investigation, the mastitis was found to be of the pyogenic type, which is transmitted largely by flies during the summer months.

Excellent results were obtained from the use of a vaccine with which every female animal in the herd was inoculated. It was at first intended to keep controls, but the trouble was so serious from the owner's point of view that this was not done. Previous to the general inoculation, the effects of the vaccine were noted on several actually affected cases, from which the udder secretion was a mixture of blood and pus. On these cases the vaccine undoubtedly appeared to exercise a beneficial effect, so that the general inoculation was finally decided upon.

The owner reports that there has not been a single case of mastitis during the whole summer, and that the affected cases which were inoculated in the first place, also recovered. In spite of the fact that no controls were kept, it cannot be said that these results are coincidental or accidental, as the summer has been exceptionally favourable for flies, and conducive to the spread of summer mastitis from which, as previously mentioned, the premises had never been free for years past.

Red water.—Investigations are still proceeding into this disease in the west of the area, where three different forms are reported locally to occur. In some instances ticks are definitely recognised by the farmers as connected with the condition, but in other districts they blame the ingestion of the leaves of various trees, but do not appear to be in agreement as to any particular tree.

Titles of papers issued during the year.

1. Bisset, N.: Stomach worms in sheep. *Western Mail Agric. Supp.*, 1933.
2. ————: Some diseases of sheep in Brecon and Radnor. *Brecon and Radnor Agric. Quarterly Gaz.*, **1**, 1, February-April, 1933.
3. ————: A deadly disease of fowls in Brecon and Radnor. *Ibid.*, **1**, 1, February-April, 1933.

94. HARPER ADAMS AGRICULTURAL COLLEGE

Cattle diseases.—Observations have been carried out upon the control of Johne's disease and upon lactation tetany in cattle.

In co-operation with the Institute of Animal Pathology, Cambridge, a new type of tuberculin, grown upon synthetic media, has been tested in comparison with ordinary tuberculin used in the intra-dermal test for cattle in the diagnosis of tuberculosis.

Poultry diseases.—Research in connection with a number of poultry diseases, including diseases of the blood forming organs and enteritis of unknown origin, is in progress. Observations upon coccidiosis, neuro-lymphomatosis, fowl pox and avian tuberculosis have also been carried out.

It is interesting to observe that two outbreaks of fowl typhoid have been diagnosed by the laboratory during the year.

Parasitic diseases of poultry, particularly tape worm infestations, have occurred in increasing numbers and the seriousness of the need for control of this condition has become very evident.

Experiments upon the value of the intra-dermal tuberculin test in the diagnosis of tuberculosis in poultry have been carried out.

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95. LEEDS UNIVERSITY

"Tremblings" or moss illness in ewes.—There was little opportunity for experimental treatment of this disease last spring as very few cases were reported. In one outbreak, however, the injection of calcium gluconate solution was followed by the recovery of eight out of ten ewes affected.

Haemorrhagic septicaemia in sheep.—A severe outbreak of this disease associated with parasitic gastritis was investigated in consultation with the veterinary practitioner in attendance.

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96. LIVERPOOL UNIVERSITY

Wastage due to disease in the dairy herds of Lancashire.—A survey has been carried out to ascertain the reasons which render necessary the disposal of a cow or heifer from the dairy herd during a specified period. This information will then be correlated to conditions and methods of management known to exist on the farm and as far as possible it is proposed in due course to define the influence of various factors on this wastage figure. Approximately thirty farmers co-operated in the scheme. Data have been supplied covering the disposal of 110 cows from 17 herds. Due allowance is made for non-wastage disposals in the ordinary course of trade and herd management.

The primary object is to measure the disease factors. The survey possesses facilities for estimating other factors such as method and avenue of disposal, depreciation, influence of breed, age, etc., the effect of home bred and purchased stock, veterinary advice, etc.

Control of streptococcic mastitis.—An attempt has been made to control serious outbreaks of this disease in six herds in the area, using a combination of clinical examination, chemical test for reaction and herd data as the basis for a grouping system. The object is primarily to test the efficacy of the method as a means of control eminently suitable to the general practitioner and the field control of the condition.

The chemical test, prior to milking, is applied to freshly drawn samples of milk using bromthymol blue solution as an indicator of chemical reaction. An alkaline reaction as indicated by a colour change through varying shades of green being accepted as positive. The method is based on the work of Udall and Johnson in America, but possesses various modifications.

Clinical examination, after milking, combined with careful examination of the history sheets of each animal completes the examination, and on the results obtained the herd is grouped into three sections.

Results would appear to indicate that the grouping system on this method is worthy of development. The indicator is not regarded as an accurate diagnostic agent but practitioners are of the opinion that it will pick out a slightly abnormal quarter of the udder which even a careful clinical examination might miss.

Johne's disease.—Two herds were tested with Johnin during the year. Experiments in connection with the eradication of Johne's disease have been in progress in selected herds for a number of years and there now exists a series of records of post-mortem reports and test readings.

Experiments with Phlein, a substance prepared from *M. phlei* on lines analogous to Johnin have been discontinued in view of the negative results obtained from its use in several herds.

It is proposed to prepare Johnin from local strain of *B. Johne* for further experiments.

Ascariasis in pigs.—The eradication of ascaris infection in a pedigree herd of swine in Lancashire is now approaching completion. The modified McLean County System and oil of chenopodium treatment combined with microscopical examination of individual samples of faeces has been productive of highly successful results. A breakdown during the year was traced and eradicated and results over the past few months bear every indication that the herd is now clear.

Title of paper issued during the year.

Mullen, A. L.: Bovine contagious abortion. *Lancs. Milk Rec. Soc. Yr. Bk.*, 1934.

97. MIDLAND AGRICULTURAL COLLEGE

Bovine Tuberculosis. Prophylactic treatment by vaccination.—This work has been carried out for some years, and in the past year two vaccinated animals have become available for post mortem examination. Both showed evidence of tuberculosis and in one the lesions were well marked.

Avian tuberculosis.—Further trial has been given to avian tuberculin as a diagnostic and from the results of post mortem examinations it appears that the test is reliable where the disease is not advanced. In many instances birds showing clinical symptoms have given no reaction to the test. This does not detract from the value of the test.

Eruption in the udders of ewes.—One outbreak was encountered in which an eruption showing papule, vesicle, and pustule stages was present. On investigation the cause was considered to be infection derived from cow manure that had been spread over the field a short time before the animals were turned on to graze. Removal from this field checked further spread.

Abortion in ewes.—Inquiry was made into one outbreak. The flock was made up of three breeds and the condition was seen in all three. An interesting feature was that only gimmers were affected. This condition has been encountered on other farms in the same area (Lindsey), and is one in which it is proposed to make further investigation.

" Blackhead " in turkeys.—Tests were made with arsenical products as curative agents, but the results obtained were inconclusive.

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98. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY

Lamb dysentery.—This disease is generally regarded as preventable by biological control, and the success of serumisation of newly-born lambs has been an outstanding and spectacular feature of the disease. Two cases, however, of what appeared to be almost complete failure of serum treatment were reported. After consultation with the manufacturer it was decided to run a carefully controlled experiment on these farms next year. It is hoped that this will produce valuable evidence connected with the strain and serological types of *B. welchii.*

There is still a lack of definite evidence that the so-called " powder " treatment of newly-born lambs has the slightest value in preventing dysentery; on the contrary such treatment of the newly-born seems irrational and the process may be definitely harmful.

Braxy or sickness in hoggs.—This disease occurs widely over the breeding areas on both sides of the Cheviot Hills. Biological control is now on a satisfactory basis, and the usual vaccine is a toxoided whole culture of *V. septique*, one injection only being required to induce immunity sufficient to protect hoggs against the naturally occurring disease. It is doubtful whether the analogous disease in young lambs (grass ill) lends itself to control in quite the same way. Experiments, however, are being continued.

Cripples in lambs.—Experimental work was commenced on this disease in November and as a result data have been collected relating to its etiology and pathology. The results of the year's work are now being prepared for publication, but it may here be stated that the nutritional aspect of the disease does not appear to be so important as was indicated by the preliminary work.

Pining or vinquish in sheep.—An opportunity occurred to inspect several flocks affected with the above disease, which is an old-established and well-recognised malady widespread on the border counties. The disease is of considerable economic importance and it was decided to institute several experiments with the object of probing the matter more deeply. Experiments were therefore started upon two affected farms, and these are being continued. Evidence so far collected does not lend any support to the idea that pining is caused by a deficiency of iron.

Parasitic gastritis in cattle and sheep.—In a grazing country such as the North of England with its large acreage of permanent pastures, it is not surprising that parasitic gastritis should rank as a very important disease. Several considerable outbreaks in cattle and sheep have been diagnosed, and in conjunction with the owner's veterinary surgeon the appropriate advice given. It is remarkable how often the above trouble is diagnosed as Johne's disease, which in its clinical manifestation it closely resembles.

Bovine contagious abortion.—Working in conjunction with several veterinary practitioners, work on the elimination of contagious abortion has been continued. No new eradication schemes have been taken on, but the adviser has had several enquiries with regard to the eradication of the disease from dairy herds. It is hoped to publish in the near future data connected with the costs of the eradication policy on one farm.

Titles of papers issued during the year.

1. Stewart, W. L.: Asthenia in piglings. *Vet. J.*, **88**, 10, 421, 1932.
2. ————: "Cripples" in lambs. *Ibid.*, **89**, 2, 63, 1933.

99. READING UNIVERSITY

Contagious abortion.—An endeavour is being made to persuade a number of suitable farmers in the province to adopt the system of eradication by blood testing and maintaining a self-contained herd. A number of dairy farmers have already acquiesced.

Cow pox.—One extensive outbreak was investigated in which the milkers and those having to do with the affected cows were themselves showing lesions similar in nature to those of the cows.

Poisoning.—A number of cases have been brought to the notice of this department and every endeavour has been made to secure adequate data, but this has frequently proved difficult. The particular plants which have been under suspicion include *solanum dulcamara*, waterdropwort, ergot and wild parsnip.

Goats.—A large herd of British Alpine goats has been under observation for a period of six months. The original complaint was a condition resembling goitre, in the young females, which disappeared spontaneously with advancing age. There was also some sterility and the complaint of low butter fat, which, with the assistance of the physiologist, are under investigation.

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100. SEALE-HAYNE AGRICULTURAL COLLEGE

Poultry.—Attempts at treatment of so-called fowl paralysis associated with chronic coccidiosis in the pullet stages of growth, and coccidiosis in the chick stages of growth, were made with various arsenical preparations. Those upon chicks will be continued.

Silver foxes.—A survey of the parasitic diseases of silver foxes was instituted by the finding of two species of lung worms (*Crenosoma vulpis* and *Capillaria aerophilia*), and two round worms of intestines (*Toxocara canis* and *Uncinaria stenocephala*). Preventative measures have caused marked improvement on the affected farm.

Cattle and sheep.—An outbreak of abortion in ewes was traced to an atypical *B. abortus ovis* organism. Cattle on the same farm were negative to *B. abortus bovis* antigen following abortion, while positive to the same germ isolated from aborted lambs. The ewes were found to give definite agglutination reactions to the causal germ. These findings are being followed up. In cattle two types of "dead" vaccines have been tested out against abortion, one being killed by formalin and the other phenol. No marked difference in reaction has shown up, and so far the results have been satisfactory, but it is as yet too early to form any conclusion.

101. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE

" Struck ".—The incidence of this disease last season was very low and accordingly no material advance was made in the study of the disease in the field. Field vaccination experiments yielded no positive information.

Gas gangrene.—Supplies of " gas gangrene " serum made at the laboratory were distributed to a number of farmers. The value of the serum as a prophylactic against " gas gangrene " in the parturient ewe was favourably reported on and it is intended to test the serum again next spring. It is possible that the inoculation of serum may become an accepted method of preventing the disease in ewes.

Johne's disease.—Last year Johne's disease was reported as causing heavy loss in a flock of sheep. The infected and other flocks where the disease was unknown were tested with Johnin but no reliance could be placed on the results. Accordingly an attempt was made to control the disease by removing all unthrifty sheep from the flock and by improving their water supply and during the winter the flock appeared in good condition. Some time after lambing, however, one or two cases of the disease occurred, but the incidence this year was very materially reduced.

It is important to observe that at post mortem examination many affected sheep failed to show any appreciable thickening or corregation of the mucosa of the intestine, which changes are regarded as so characteristic of the disease in bovines. Smears made from the intestinal mucosa generally showed very large numbers of acid fast bacilli but in exceptional instances no bacilli were found. Histological preparations of the intestine, however, showed nests or collections of epitheliod cells in the mucosa which were characteristic for all cases examined and may be regarded as diagnostic.

Numerous attempts were made to cultivate the bacilli which were abundantly present in the intestine and the associated lymphatic glands, but in no instance was growth obtained although the medium used was similar to that upon which bovine Johne's bacilli are readily cultivated. Various modifications of the medium were also tried but without success. There is, therefore, reason to suspect that the bacilli were not identical with those commonly causing Johne's disease in cattle.

Unfortunately, owing to the complete absence of facilities for maintaining any of the farm animals under experimental conditions, it was impossible to attempt infection experiments of calves and ascertain the effect of the bacilli on these animals.

Contagious abortion.—Work on the control of this disease by blood testing and separating the reactors from the non-reactors proceeds with encouraging results, particularly in those herds

where there is a conscientious and earnest effort made to take all reasonable precautions to prevent the disease spreading. It is generally regarded that the results amply justify the efforts. The expense of the work to the farmer has been negligible in the majority of cases and the gains considerable.

Immunisation experiments, using laboratory animals, are in progress but it is too early to anticipate the results. Each experiment runs a prolonged course and accordingly results cannot be rapidly obtained.

In one or two herds where it has been impracticable to control the disease by segregation of the infected, animals which were negative to the agglutination test and presumably not infected are being vaccinated every two months with a living culture of *Br. abortus*. Pregnant and non-pregnant animals alike are vaccinated. No untoward results have attended this work; the vaccine has not caused abortion. It is, however, difficult to estimate the protection it may have conferred as the total number of vaccinated animals is not large and it has been impossible to keep controls, owners being unwilling to leave non-infected animals unvaccinated.

It is hoped that in time the use of the treatment may be estimated.

It is considered most important to vaccinate non-infected cows only, even when these are non-pregnant. When non-pregnant infected cows are vaccinated and subsequently calve normally it is quite unjustifiable to attribute the normal calving to the result of vaccination. Despite this fact vaccine is constantly being inoculated into infected animals. The practice may be harmless, but it vitiates any true interpretation of the value of the vaccine.

Titles of papers issued during the year.

1. Roberts, R. S.: The practical value of the Heat-Stable antigen of *Ch. chauvoei* as an immunising agent. *J. Comp. Path. and Thera.*, **46**, 56, 1933.

2. McEwen, A. D.: " Struck ", enteritis and peritonitis of sheep caused by a bacterial toxin derived from the alimentary canal. *Ibid.*, **46**, 108, 1933.

3. ————: A brief review of the researches on the acute diseases of sheep on the Romney Marsh. *J.S.E. Agric. Coll.*, 32, 171, 1933.

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AGRICULTURAL AND DAIRY BACTERIOLOGY

102. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES

Thermophilic and thermoduric flora of raw milk.—The number of organisms capable of growing at 145° F. was studied in two types of raw milk. It was found that all the 21 samples of milk of very poor hygienic quality from a certain farm showed the presence of true thermophiles. In the case of a series of 56 samples of Grade A (T.T.) milk of exceptionally good hygienic quality, thermophiles were demonstrated in 21 per cent. by microscopical examination.

Grading milk by microscopical examination.—It has been found that the smearing of one-tenth of a c.c. of milk over the entire surface of a 3 × 1 inch slide offers distinct possibilities as a method for the enumeration of the bacterial content of milk.

A comparison of the bacterial counts obtained on milk agar and on standard agar.—A series of 265 milk samples were plated on standard agar and on standard agar plus 1 per cent. sterile milk. The resulting bacterial counts have been compared, and the use of milk agar has been shown to have certain advantages.

Ice cream and clotted cream.—Experimental work is being conducted at the College Dairy on the manufacture of ice cream from dairy products, and the production of clotted cream. Samples of both products at different stages of manufacture are examined bacteriologically.

Titles of papers issued during the year.

1. Thomas, S. B., and Hickson, P. M.: Bacteriological examination of milk from Welsh county clean milk competitions. *Welsh J. Agric.*, **9**, 224-240, 1933.
2. ————: Monthly variations in the fat content of milk from Welsh farms. *Ibid.*, **9**, 241-248, 1933.

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103. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES

" Ropy " cream.—Investigation showed the cause of this condition to be in the eartherware crocks in which the milk was set. Samples taken straight into sterile bottles failed to show any sign

of ropiness but ropiness developed rapidly in samples from the crocks. After the crocks had been thoroughly cleansed and scalded no further trouble was experienced.

Mastitis due to coliform organisms.—This investigation was carried out in co-operation with the advisory veterinary department. Several cows in the herd were found to be giving considerable amounts of pus in their milk though there were no clinical signs of inflammation in the udders. There was also a somewhat high coliform content in the milk. Samples of milk taken direct from the udders of the suspected cows were examined microscopically and some of the sediment was also plated out on blood agar. Numerous haemolytic colonies were isolated, and microscopical examination revealed that they were Gram negative bacilli, and their reaction to various sugars relegated them to the *Bacillus coli* group.

Rapid souring of milk.—An investigation into this problem resulted in the discovery of one cow with an affected quarter. Considerable numbers of streptococci were isolated from the sample from that particular quarter. The rapid souring of the milk was probably due to the heavy infection with *B. coli* as a result of the generally poor conditions of production. Advice was given regarding more cleanly methods of production, and since the removal of the affected cow from the herd no further trouble has been experienced.

High coliform content.—Cases of abnormally high coliform content have generally been found to be due to faulty methods of production, the trouble being inefficient washing of the cows.

Titles of papers issued during the year.

1. Hickson, P. M., and Thomas, S. B.: Bacteriological examination of milk from Welsh county clean milk competitions. *Welsh J. Agric.*, **9**, 224-240, 1933.

2. ————: Monthly variations in the fat content of milk from Welsh farms. *Ibid.*, **9**, 241-248, 1933.

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104. BRISTOL UNIVERSITY

Methylene blue reductase test.—Much data have been accumulated relating to this method of testing samples of milk, and an article embodying the adviser's observations has been published (1).

Thermal insulation of milk samples.—An investigation on the thermal insulation of milk samples during transit by post has been carried out and a report issued.

Hand milking versus machine milking.—A short investigation on the relative merits of hand and machine milking in the production of clean milk is being carried out.

Title of paper issued during the year.

Miles, C. S.: Some observations on the methylene blue reductase test. *J. Min. Agric.*, **40**, 5, August, 1933.

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105. CAMBRIDGE UNIVERSITY

Butter-fat content.—A statistical investigation into milk yield and butter-fat percentage at individual milkings was undertaken. The data comprised the yield, in pounds, of milk and the butter-fat percentage of individual-cow tests covering the first five consecutive visits of the milk recorders during five hundred lactations of Shorthorn cows. The evening and morning results were considered separately, each set being divided into five groups corresponding to the visits of the recorders. The successive visits made, at an average interval of six and a half weeks, indicated roughly the stage of lactation. Correlation of yield and butter-fat percentage was subsequently undertaken.

Preliminary work has been done on the rising of cream in milk as it affects the butter-fat content of successive quantities of milk withdrawn from a delivery vessel.

Scarlet colouration.—A case of scarlet colouration occurring in milk residues present in bottles returned to the dairy was investigated. The causal organism was identified, but the source was not traced. Steam sterilisation of utensils provided effective control.

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106. HARPER ADAMS AGRICULTURAL COLLEGE

Reductase test.—687 comparisons of the methylene blue reductase test at 15°C. with the usual keeping quality tests have been carried out during the year. Methylene blue in a concentration of 1 : 300,000 was used, the tubes were not shaken and were examined when the keeping quality test was being carried out. The results were promising and the experiment is being repeated but the tubes are being taken at half-day intervals.

Bacteria in hen and duck eggs.—Some work has been carried out on the mode of infection of the eggs but results have so far been negative.

107. LEEDS UNIVERSITY

Milk and cream investigations.—During the year investigations have been carried out on problems concerned with the cause of (i) the poor keeping quality of milk, (ii) taints and abnormal flavours in milk and cream, and (iii) the detection of latent mastitis in milch cows.

In the majority of cases of poor keeping quality and abnormal taint, the cause was generally found to be insufficient preparation of the cows and unsterile utensils.

" Foul brood " of bees.—An investigation was carried out during the summers of 1931 and 1933 into the cause of " foul brood " of the honey bee larvae. This investigation has shown that the causal organism of foul brood, in the form in which it occurs in this country, is propably due to *Bacillus larvae* (White) and not to *Bacillus alvei* as stated by Cheshire and Cheyne. Much work, however, remains to be done before suitable methods of control of the disease are furmulated (1).

Titles of papers issued during the year.

1. Chalmers, C. H.: " Foul brood " of the honey bee. *Nature*, **132**, 751, Nov., 1933.
2. ————: Some observations on species of actinomyces found in samples of milk. *Lent. f. Bakt.*, **11**, 87, 1932.

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108. MIDLAND AGRICULTURAL COLLEGE

Flavour of milk.—The effect of A.I.V. lucerne silage on the flavour of milk was investigated. The basal ration was 28 lb. kale, 20 lb. swedes, and hay. The experimental group received 40 lb. lucerne silage instead of hay, 20 lb. being fed after the morning milking and 20 lb. before and during the afternoon milking. No off flavour was detected in the milk of any of the experimental animals.

Sterilisation of utensils.—These experiments were carried out during winter months on a farm where it is the usual practice to use only cold water for washing the dairy utensils. The cows were kept clean and open pails were used for milking. During the first period of the experiment the utensils were simply washed in cold water, but for the second period they were steamed after washing. The results obtained showed that the utensils are a source of bacteria as well as coliform organisms, and sterilisation greatly reduces both.

Mastitis.—The presence of pin point colonies on agar plates from milk has again been found to indicate mastitis in some cases. The introduction of new medium (milk agar) for routine work has

resulted in the previously pin point colonies becoming larger. Even with the new medium it has been possible to detect mastitis in some cases, especially in the absence of coli in the milk.

" *Ropy* " *milk.*—Investigations have shown that " ropy " milk bacteria are very common in raw milk samples. The milk from about 50 farms is being examined at monthly intervals to determine the extent of the infection, and if opportunity arises the source of the bacteria will be determined in the case of farms found to contain the specific organisms persistently.

Titles of papers issued during the year.

1. Rowlands, A.: The keeping qualities of milk. *Farmer and Stockbreeder*, **47**, 17th April, 1933.
2. ————: Brailsford clean milk competition. *Derbyshire Farmer*, **13**, 9, Sept., 1933.

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109. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY

Contagious abortion.—An experiment commenced in 1930 in conjunction with the adviser in veterinary science on the eradication of contagious abortion has now been completed and a report prepared for publication. The herd on which the experiment was made was one in which contagious abortion was present and where breeding was irregular, the general health of the animals indifferent, and where sterility, nymphomania, granular vaginitis and mastitis were troublesome. All animals in the herd were blood tested monthly and reacting animals segregated. The method of blood testing and the interpretation of the results are detailed in the report on the experiment. In a period of six months contagious abortion was eradicated from the herd. The herd has now been free from infection for 32 months. The general health of the animals is now satisfactory and none of the disabilities, prevalent in the herd at the commencement of the experiment, remain.

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110. READING UNIVERSITY

Duplicate testing scheme.—The preliminary analysis has now been completed. At the 1/10 dilution two samples were significantly different when the ratio of their geometric mean colony numbers was greater than 1:6; the corresponding figures were 1·8 at 1/100 and 1·5 at 1/1000. Thus in terms of colony numbers the three dilutions were equally accurate but in terms of " number

of bacteria per c.c." the 1/10 dilution was roughly ten times as accurate as the 1/100 and the 1/100 ten times as accurate as the 1/1000.

The data are now being rearranged for further analyses.

Correlation scheme.—The data recording is almost complete but analysis cannot be proceeded with until the analyses of the duplicate testing scheme are completed.

Testing of ice cream.—The work on ice cream which was commenced last year has been temporarily discontinued.

Types of cells in milk.—Some preliminary investigational work has been done but no results are yet available.

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111. SEALE-HAYNE AGRICULTURAL COLLEGE

Taint of clotted cream.—A large producer of clotted cream was troubled with a taint which rendered the cream that he produced totally unfit for sale. On investigation it was found that nine cows (out of a herd of thirty-two) were suffering from streptococcal mastitis, and the taint ceased when the milk from these cows was eliminated from the bulk.

Bitterness in clotted cream.—Several more cases of this defect have been investigated and found to be due to spore forming organisms of *B. mycoides* type. These organisms seem to gain entrance to the cream from (i) the cream being placed to " set " in places where it is liable to become contaminated with dust, (ii) the coats of cows when pastured in marshy meadows, (iii) the water supply used for washing the utensils.

Contaminated water supplies.—There is scope in both Devon and Cornwall for much more work to be done on contamination being due to faulty water supplies, as a very large percentage of farms in both these counties are using water derived from wells. Several cases have been proved of coliform contamination being due to the use of water contaminated with these organisms for washing the udders of the cows previous to milking.

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112. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY

Samples of milk have been taken to show the effect of mixing on the fat and bacterial contents. The results await a preliminary examination.

The results of tests by Van Oijen's method have been examined and a report published (3). A further investigation will be undertaken.

A survey of reported milking times was made, and also a new tabulation of the bacteriological results of the past seven years has been completed and the results examined statistically.

Titles of papers issued during the year.

1. Barkworth, H.: Milking times. *J. S.E. Agric. Coll.*, 32, 189-193, July, 1933.
2. ————: Coliform organisms and keeping quality of milk. *Ibid.*, 32, 194-196, July, 1933.
3. ————: Van Oijen's test. A rapid method for counting high class milk. *Ibid.*, 32, 197-201, July, 1933.

113. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE

Milk faults.—An aroma resembling that of amyl alcohol.—A detailed account of the investigations carried out in connection with this taint was published in the Journal of Dairy Research (1).

The Burri smear-culture method for determining the bacterial content of milk.—The investigation of the accuracy of the Burri smear-culture method was completed and the results prepared for publication. The data show that the percentage error in the smear-culture technique is markedly higher than that in the ordinary plate method. Evidence is presented in support of the view that this is partly due to the errors involved in loop measurements and partly to the inferiority of the conditions for growth on slopes to those in plate cultures.

Coliform organisms in milk samples.—As was indicated in the last report, Dr. G. Glathe of Leipzig obtained promising results here with a solid medium (acriflavine-bromthymol blue agar) for the enumeration of the coliform organisms in milk. 1 in 100,000 acriflavine inhibited practically all the non-coliform organisms in the milk samples examined, but exerted little or no inhibitory influence upon the coliform bacilli in the majority of the samples of cows' faeces tested. Further work with the medium, however, has shown that the inhibition of non-coliform types is not always as complete as the first experiments indicated, and that the colonies of coliform and other organisms which grow upon the medium cannot always be differentiated by their appearance. While the acriflavine medium cannot at present be recommended for use in routine milk examinations, it may prove to be useful in work in which the identification of the bacilli is not entirely dependant upon the appearance of their colonies. A paper summarising the results so far obtained was read at the Conference of the Society of Agricultural Bacteriologists in July (2).

The anaerobic bacilli of farmyard manure.—The preliminary work on this subject was completed and a short paper prepared for publication in the Journal of Agricultural Science. Considerable numbers of anaerobic bacilli were found in the samples examined

and *B. sporogenes*, *B. bifermentans*, *B. tertius*, *B. tetanomorphus* and *B. saccharobutyricus* were isolated. Anaerobic decomposition of cellulose was observed in media inoculated from both of the samples of Edelmist (hot-fermented manure) examined. This observation is of interest because of the fact that it has been generally believed that after the first few days little or no microbiological activity takes place in this material.

The microflora of A.I.V. silage.—It is claimed that the addition of acid to grass and other materials employed in the making of A.I.V. silage suppresses or at least controls microbiological activity. Five samples of A.I.V. silage were examined. In some of the samples considerable numbers of micro-organisms, mainly of types similar to those occurring in ordinary silage, were found. It is doubtful, however, whether the samples could be regarded as truly representative of the best A.I.V. silage. It is hoped to continue these observations during the coming year on additional samples of A.I.V. silage.

Disease of dahlias.—A disease of dahlias bearing some superficial resemblance to streak of sweet peas and other plants was investigated. Infection experiments were carried out, so far, however, with negative results.

The filterable phases of bacteria.—Attempts to cultivate filterable phases from old cultures of bacteria have been unsuccessful.

Urea-decomposing micro-organisms of soils and manures.—The investigation of the urea-decomposing micro-organisms of soils and manures was continued. A search was made for the agents concerned in the hydrolysis of urea in a variety of soils and a considerable number of pure cultures has been investigated. The majority of the organisms are related to *Bacillus Pasteuri*. Of the less prevalent types, few appear to have been isolated by earlier workers. An effort is being made to classify the various types, and where possible to compare them with cultures obtained from abroad. In addition to the systematic work, a study is being made of the conditions under which the organisms are capable of growing in soils and manures. A preliminary paper giving the results of some of this work was read to the Society of Agricultural Bacteriologists at the annual meeting in July, 1933 (3).

Root-nodule bacteria.—An investigation of the root-nodule bacteria of ulex, cytisus, genista and laburnum was carried out and inoculation tests made with pure cultures on plants grown under bacteriologically controlled conditions.

Titles of papers issued during the year.

1. Cunningham, A.: A bacterial milk taint. *J. Dairy Res.*, **4**, 197-205, 1933.
2. Cunningham, A., and Glathe, G.: An investigation of certain solid media for the selective cultivation of coliform organisms from milk samples. Papers read at the Conference of Agricultural Bacteriologists, 1933.
3. Gibson, T.: A study of the *Bacillus Pasteuri* group. Papers read at the Conference of Agricultural Bacteriologists, 1933.

114. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE

Milk Production.

Proven sires.—The work on this continues and all breeds are being considered. So far 99 bulls with a total of 1,695 high producing daughters have been included in the list. The bull highest in the list has 60 daughters.

Good breeding dams.—A list of 98 good breeding dams has been prepared. The best of these has seven high producing daughters.

A.I.V. fodder.—The dry matter in this new feed is of about the same value for milk production as the dry matter in swedes. When fresh green material such as aftermath is preserved in this way it improves the colour of milk during the winter.

Potatoes.—Investigations show that on the dry matter basis potatoes are equal to swedes.

Silage crops.—Artichokes and sunflowers are being tested as silage crops.

Pasteurised milk for calves.—It has been found that calves fed on raw milk make greater progress than those fed on pasteurised milk. Those given raw milk for 10 days followed by a pasteurised milk diet thrive more than those given raw milk for five days only. Bulls thrive relatively less on pasteurised milk than do heifers.

Hoven in dairy cattle.—This condition is now believed to be due to the presence of a saponin in clover and other plants. Work on this problem is being continued.

Indigestion in calves.—A digestive disturbance in calves was found to be due to a hard curd milk. It was overcome by the use of a sodium citrate solution.

Milk Utilisation.

Mastitis.—By far the commonest cause of milk defects was the incidence of bovine mastitis, the contagious form of which appears to be on the increase in the dairy herds of S.W. Scotland. A non-haemolytic streptococcus was the causal organism most frequently observed in the milk of affected herds, but in a number of cases a haemolytic staphylococcus was the prevailing mastitis-producing organism observed. In one herd of 72 cows, the milk of which was unusually difficult to manufacture into cheese, 50 of the animals were shown to harbour a haemolytic staphylococcus infection when reference was made to the fresh aseptically drawn individual samples. Haemolytic streptococci were found to be present in the milk of 26 out of 30 cows in a Grade A. (T.T.) herd; the milk of affected cows had a most objectionable flavour.

Ropy milk.—Several outbreaks of ropy milk were investigated, the source of the organism determined, and appropriate control measures applied with success.

Oily milk.—The development of oiliness after 16 to 20 hours in the well cooled milk of a dairyman was found to be associated with a high copper content in the milk (1·65 p.p.m.), the copper having been picked up from a large brass wire strainer used for filtering the milk—which was not otherwise treated. Laboratory tests showed that a 15 seconds contact of fresh normal milk with the brass screen actually doubled the copper content of the milk and produced a marked oily flavour in the milk when stored at a low temperature. Cheese made from such milk had a considerably higher copper content than cheese made from the same milk not passed through the strainer.

Faults in cream.—The souring and deterioration of sterilised cream prepared by a dairy factory was found to be due to an external infection after canning, arising from the faulty structure of some tins which allowed of an almost imperceptible leakage along the lateral seams. Both streptococci and bacilli were found in the affected cream.

Faults in butter.—A number of farm butters showing defects such as tallowiness and rancidity, burnt or caramel flavour, and bitterness were examined. A common cause of bitter rancid butter was a lipase enzyme associated with the milk of cows in advanced lactation; while the burnt flavour was caused by starter organisms which had acquired this undesirable characteristic of producing a burnt flavour in the cream. Marked deterioration in butter made from raw cream was found in several cases to be associated with large numbers of leucocytes present in the primary milk.

Butter experiments.—An experiment to determine whether the addition of small quantities of maleic acid (1 :10,000) to cream would improve the stability of the butter made from it did not yield significant results.

In feeding experiments it was found that swedes produced milk from which a better quality of butter could be made than from A.I.V. silage or potatoes. A.I.V. silage, however, produced a higher coloured butter, while the effect of the potatoes was to produce an almost dead white colour and poor keeping properties.

Faults in cheese.—In connection with the investigation of discolouration of the bleaching type in annatto coloured cheeses, a medium has been devised in which the decolouring effect of micro-organisms present in affected cheese can be clearly demonstrated. Investigations hitherto conducted with this medium have failed to show that moulds have any specific effect in inducing discolouration while certain groups of bacteria will slowly discharge the annatto colour. The source of these organisms is being investigated.

Starters.—Over 2,000 cultures have been issued during the past year. Starter investigations relate to the isolation of strains productive of a good flavour in butter and in cheese, to laboratory methods which will give a correct index of the activity of different starter cultures before they are issued to the dairy industry, and to the cause of loss of vigour in starters grown under controlled conditions.

The selection of aroma producing starter cultures on a basis of their acetyl-carbinol production has been attempted, but it has been found as a matter of practice that the smell of the ripe milk culture is as good an index of aromatic qualities as the differential test for diacetyl production.

Titles of papers issued during the year.

1. Leitch, R. H.: Foods and flavour in milk. *West of Scotland Agric. Coll. Bull.* 126, 1932.
2. ————: L'arrêt de la fermentation lactique dans la preparation du fromage. *Le Lait*, **13**, 125, May, 1933.
3. ————: Recent developments in buttermaking. *Proc. Aberdeen Poultry and Dairy Conf.* D.A.S. Memo.
4. ————: Temperature control in milk and in milk processing. *Milk Trade Gaz.*, **6**, 76, June, 1933.
5. ————: Lack of body in cheese; firming of cheese curds. *Scott. Farmer*, **41**, 526-527, 562, 1933.
6. ————: Milk and its physical properties. *The Milk Trade and Dairy Industry*, 1, 247-260, 1933.
7. ————: Pasteurisation in the manufacture of dairy products. *Ibid.* 1, 204-214, 1933.

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ECONOMICS

115. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES

Farm management accounting.—General financial accounts of 76 farms are now being dealt with. General analyses have been made of the whole of the accounts for the year 1932-33, with a great deal of comparative analyses for the accounts which have been kept for four years. Two cost accounts are still kept.

Cost accounts of the Cahn Hill Improvement Scheme for experiment and demonstration in the improvement of hill-grazings have been started and arrangements for the keeping and analysis of accounts of poultry farms or of fairly large poultry enterprises of general farms have been made. Records for some 34 of these accounts are now arriving fairly regularly.

Farm management analysis.—Analyses of farm accounts indicate that the most satisfactory results are obtained on farms where more labour than the average is used, but what is equally if not more important, where proportionately more of other resources relative to labour are used. The general results support the conclusions of a previous study—to the effect that even during this period of depression higher profits are earned on the more highly farmed holdings.

Changes in farming.—Studies of changes in the farming of the counties of Norfolk and Lincolnshire have been completed. Such studies contribute to the general knowledge of economic movements and conditions.

Horticulture and intensive cultivation.—As an incident of a study of prices of tomatoes and cucumbers and of other products of intensive cultivation, the possibilities of developing some of the more intensive forms af cultivation in Wales have been studied. Efforts were made to obtain information on the financial aspects of glasshouse production.

Rural electrification.—In view of keen interest of farmers of some districts in the uses of electricity on farms and in farm houses and of their questions on the economy of installing electric plant, a study of these problems has been made. With the co-operation of a local power company a survey was made in South Wales and 57 holdings were visited. Data were obtained relating to the uses to which electricity was put, the cost of installation, for lights and power, outlay on equipment, the amount of current taken and its cost.

Much useful information was also obtained about the seasonal distribution in the use of current and about tariff rates. Interest in this subject continues and some further and somewhat more detailed studies are being planned.

Survey of fruit and vegetable trade in North Wales.—A survey of the supply and consumption and the intermediate trade in horticultural produce in North Wales was undertaken. Thirteen towns in the four counties were selected for the investigation which covered, as regards supplies and sale, 12 vegetables and fruits of which there is a local supply. In addition to information on quantities purchased and sold, information was obtained on sources of supply at different seasons of the year, quality and packing or presentation of local produce, wastage on local and other supplies, and on consumers' demands. Also the opportunity was taken of making a survey of the general structure of the trade in fruit and vegetables in North Wales.

Altogether, the survey has been remarkably successful. The information is of great interest and should prove to be of practical utility both in showing opportunities for some economic developments in growing and marketing horticultural produce in North Wales—and, probably not less important, of showing how some markets may be filled to overflowing if unmeasured or misdirected developments occur. One of the very striking features of the results is the evidence of low purchase (and almost certainly low consumption) of fruits and vegetables in certain towns; and another, that of the quite unexpectedly high proportion of supply of some products that proved to be " local grown."

Prices investigation.—An elaborate analysis has been made of prices of milk and dairy produce, and of cows, and of the interrelations between prices of milk and milk-products, and of those between milk and milk-products and dairy cattle. Parts of this analysis were conducted for the period 1870-1913 in so far as data were available; but the complete analysis has been made for the post-war years, more particularly since 1924. Some further work is now being carried on, and every opportunity will be taken for preparing the results of this analysis for use, and most probably for publication.

Some analytical work on prices of vegetables has also been undertaken.

Prices of glasshouse produce.—During the year some results of a preliminary study of prices of glasshouse produce were published. This publication dealt with general supplies of tomatoes and cucumbers, general trends and seasonal variations in prices, monthly variations in total supplies, and monthly and yearly variations in the different grades in certain nurseries, and the relation of seasonal supplies to seasonal prices.

Titles of papers issued during the year.

1. Ashby, A. W., and Howell, J. P.: Dairying on second class land: An examination of changes in farming. *Welsh J. Agric.*, **9**, 1933.
2. Ashby, A. W., and Jones, W. H.: Costs of production and prices of milk: A study of some tendencies. *Ibid.*, **9**, 1933.
3. ————: Light, heat and power in rural areas: A study of uses of electricity in South Wales. *Welsh Housing and Development Yr. Bk.*, 1933.
4. Howell, J. P.: Farmers' cost of milk delivery in Wales. *Welsh J. Agric.*, **9**, 1933.
5. Davies, J. Ll.: Manual labour requirements of livestock on Welsh farms. *Ibid.*, **9**, 1933.
6. ————: Financial aspects of glasshouse production. *Ibid.*, **9**, 1933.
7. ————: Some aspects of consumption, supplies and prices of tomatoes and cucumbers. *Ibid.*, **9**, 1933.
8. ————: The outlook for sheep farming. *Trans. Northumberland Agric. Discussion Socs.*, **3**, 1932-33.
9. Williams, J. G.: The future of co-operative marketing of farm produce in Wales. *Welsh J. Agric.*, **9**, 1933.
10. ————: Memorandum on the position of landowners under the agricultural marketing schemes. *J. Central Landowners' Assoc.*, August, 1933. (Also issued by the Department).
11. Jones, W. H.: Light and power on farms: A study of uses of electricity in South Wales. Issued by the Department.
12. ————: Rural electrification. *Electrical Review*, June, 1933.
13. *Reports of Conferences on Development of Agricultural Co-operative Business.* October, 1932, and May, 1933. Issued by the Department. *Contents:* The Wheat Act, 1932. (Vigor, H. D.)
    The prospects of trade in feedstuffs and fertilisers. (Ashby, A. W.)
    The market for fertilisers, 1932. (Henderson, R.)
    Suggestions of superannuation schemes for co-operative employees. (Williams, J. Glynne.)
    Stock-taking and the principles of valuation in co-operative accounting. (Lewis, T.)
    The farmer and the consumer. (Duncan, J. F.)
    Stabilising the potato industry of Great Britain. (Mollett, Captain J.)
    The position of butter and cheesemakers in relation to the proposed scheme for regulating the marketing of milk. (Ashby, A. W.)
    Taxation of co-operative societies. (Williams, J. Glynne.)

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116. BRISTOL UNIVERSITY

Financial accounts.—Simple financial accounts have been received from 155 farmers and the data arising therefrom have been studied. Discussion meetings with the farmers concerned have once more proved the value of this method as a means of inducing farmers to analyse management problems.

Farm costing.—Three farms with a total area of 965 acres have been costed in detail under the agreed " Oxford " method. All three farms have over 80 per cent. under permanent grass and may be classified as milk producing. Requests have been received from other farmers wishing to cost their farms.

Agricultural surveys.—No surveys have actually been carried out during the year under review, but reports on the production of strawberries and willow growing surveys, carried out in the previous year, have been completed (1, 2).

Cost of production studies.—Investigations into the cost of production of strawberries and sugar-beet have been continued. In the former case 30 farms comprising 71 acres of strawberries were costed. A third year's records will now be obtained. The enquiry into the cost of production of sugar-beet, which began in 1925, has been continued and data from 11 farms in Herefordshire and Worcestershire obtained.

Dairy herd management.—A full report upon the first year's results is now in course of preparation. This investigation is not to ascertain the cost of production of milk so much as to furnish farmers with an economic analysis of their methods of management as indicated by types and quantities of feeding stuffs and labour, systems of cow replacement, and incidence and kind of disease. Thirty-two farmers are co-operating in the scheme. The size of herd varies from seven to 137 cows and altogether 1,120 cows are included.

Poultry farming.—An inquiry into the methods of management adopted by poultry farmers has been carried out and a report is in course of preparation. Thirty-five farmers having flocks ranging from 100 to over 4,000 birds co-operated and it was found that the systems of management varied considerably.

Analysis of farm accounts.—The special investigations into the application of statistical methods to farm account data are being continued. The results obtained do not justify the publication of definite positive conclusions. On the contrary, the experimental work has demonstrated that the material collected in the financial account is cast in a form which is not in any way designed to answer questions framed by the economic statistician. Even the concept "profit or loss," whilst of value to the accountant and to the Commissioners of Inland Revenue, is a fiction to the farmer and to the economist. The statistical research of the department is being directed towards transforming the data of accountancy into data which are capable of economic manipulation.

The experimental statistical work has also demonstrated how dangerous is the use of the simple arithmetic average in farm economics. Here again, transformations of technique must be accomplished. All averages must be "conditioned," that is, they must be in such a form that they change in magnitude as environmental conditions change.

Finally, a third transformation must be accomplished. Mathematical methods fail to respond to the excessive complexity and unusual curvilinearity and deviation of economic phenomena. A graphical technique is being developed.

The combination of data based on a method adapted for income-tax purposes, with a mathematical method adapted for the laboratory experiments of the biologist, will not provide a sound basis for the farm economist penetrating the problems of farm balance and co-ordination.

Titles of papers issued during the year.

1. Dawe, C. V.: An economic inquiry into the production of strawberries. *Bristol U. Bull.* 8.

2. ————: An economic survey of the Somerset willow-growing industry. *Bristol U. Bull.* 9.

117. CAMBRIDGE UNIVERSITY

Economic survey of Eastern Province.—The economic survey commenced in September, 1931, has been continued and records were obtained from nearly 1,200 farmers. The Province comprises eleven major "type of farming" areas, the boundaries of which are influenced primarily by soil type and marketing facilities, and the economic organisation of farming varies very greatly between one district and another. Quantitative measures of these variations have been obtained, and the factors influencing the profitableness of farming within each district are being studied. The results emerging from this second year's study have been published (8). The financial returns secured by farmers in 1932 show a decline (excluding wheat "deficiency payments") compared with those of the previous year, and it would have been necessary for the prices of produce to be 23 per cent. higher than they actually were in order to provide a fair return on the capital invested and for the work of the occupiers. This figure of 23 per cent. compares with that of 18 per cent. for the year 1931. The "deficiency payments," however, more than offset this apparent worsening of the position, and as a result of the Wheat Act farm incomes for 1932 were actually slightly greater than in the previous year.

Milk production and marketing.—The enterprise efficiency study of milk production was continued. The economics of milk production on 18 arable farms on which milk recording is practised is being investigated. On most of these farms milk production is being carried out with great efficiency and skill, and the data obtained will provide standards of comparison for other producers. A number of the farmers co-operating in this study have obtained suggestions for effecting economies in their own herds.

The study of milk marketing schemes and price policies in England and America undertaken by Miss R. L. Cohen was completed and the results published (7).

Other production studies.—The cost of production studies of strawberries and sugar beet have been continued, but the wheat investigation was terminated with the 1932 crop.

Titles of papers issued during the year.

1. Carslaw, R. McG.: Size of fields in the Eastern counties of England. *Farm Economist*, **1**, 2, April, 1933.
2. ————: Financial results of farming in the Eastern counties of England in 1932. *Essex Farmers' J.*, Feb., 1933.
3. ————: Economic investigation of farm management problems. *Agric. Prog.*, **10**, 13, 1933.
4. Cohen, Ruth L.: The effect of different price policies on the seasonal production of milk. *Farm Economist*, **1**, 1, March, 1933.
5. Menzies-Kitchen, A. W.: The Pig Re-organisation Commission and production costs. *Ibid.*, **1**, 2, April, 1933.
6. Carslaw, R. McG., and Menzies-Kitchen, A. W.: Effect of the Wheat Act (1932) on production. *Ibid.*, **1**, 1, March, 1933.
7. A survey of milk marketing schemes and price policies. Report No. 20, 1932. *Farm Econ. Br., Dept. Agric., Camb. U.*
8. An economic survey of agriculture in the Eastern counties of England. Report No. 21, 1932. *Farm Econ. Br., Dept. Agric., Camb. U.*
9. Financial results of farming in the Eastern counties of England. (Preliminary statement for 1932). *Farmers' Bull.* No. 2.

118. HARPER ADAMS AGRICULTURAL COLLEGE

Poultry management study.—This study is now in its fourth year, and continues to expand. Completed returns are now available for three years on an aggregated flock of 45,000 birds, and an interim report is in preparation with the co-operation of other advisers. Records of incubation results have again been kept. A subsidiary investigation into the costs of pullet rearing was made, and results covering 4,000 pullets to the age of 6 months were obtained.

Milk.—The Department kept records on 14 farms, in co-operation with other advisers in the milk management study. The establishment of Marketing Boards is creating an entirely new attitude on the subject of costs in the farming community within the area.

Sugar Beet.—The Department again costed 1,000 acres of sugar beet in the area, in order to complete the work which has continued throughout the subsidy period.

119. LEEDS UNIVERSITY

Farm management.—Detailed accounts of some sixty farms are still being kept, carefully analysed, studied, and reports sent to the individual farmers concerned.

Agricultural history.—The survey of the Manor of Hooton Pagnell has now been completed and will shortly be published.

Opportunities have also been found during the year of tracing the variations in the systems of land tenure in the Manors of Slaithwaite, Aldborough, and Skipton, and of studying the old manorial customs of Bolsover, Oxcroft, Newby, Clapham, Austwick, Burton-in-Lonsdale, and Ingleton.

Miscellaneous.—The following investigations have also been completed :—

The economics of the production and disposal of peas for picking green; the rise and fall in the flax industry; the economic position of the potato crop in the county; a survey of the system of sheep management in the county; and the economics of the production and disposal of beef.

Agricultural survey of Nidderdale.—Work has been commenced on a survey of Nidderdale. Some 40 maps of the Dale have been drawn, farms in every individual parish have been personally visited, an attempt made to show the influence of the various physical, climatic, soil and chemical factors on the varying systems and methods of farming in a dale which may be looked upon as rural.

Agricultural survey of Airedale.—A similar survey is also being made of Airedale. As the Aire flows for the greater part of its course through an industrial area it was thought that a comparison of the two dales from an agricultural point of view would be interesting as well as instructive.

Smallholdings survey.—A commencement has been made of the survey of the smallholdings movement in the County, which it is hoped to complete before the end of next year.

Milk production.—A record of the milk production of 30 herds has been completed in the series of investigations that are being carried out in connection with management for milk production.

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120. MANCHESTER UNIVERSITY

Feeding for milk production.—Chief attention is still given to investigating the problem of managing pastures and meadows. The hypothesis underlying research on this subject is that on farms devoted in whole or in part to milk production a given amount of food for cows can be produced from the fields at less cost than it can be purchased from cake and corn merchants. Farmers generally are inclined to support this view, although only a small minority are willing to co-operate in the research necessary to test its soundness. By applying the starch equivalent formula to the data they have collected, the staff of the Midland Agricultural College have made a useful contribution to the technique of research. Its application to the data obtained in Lancashire

and Cheshire has proved of great assistance and value. The associated progress in management has been accelerated during the year.

Treatment of cereal seed.—Observation of the results arising from the treatment of cereal seed with a disinfectant against fungoid diseases was continued. The finer season, or more definitely the higher temperature, of 1933 compared with 1932 was so favourable to germination that the contrasts which were so marked between the crops from treated and untreated seed last year were hardly noticeable this year. This is of economic importance.

Production of Potatoes.—Figures for acreage, yields and financial returns of potatoes on a West Lancashire farm during seven years are made available. The acreage was comparatively steady while yields and returns fluctuated violently.

Titles of papers issued during the year.

1. Orr, J.: Investments in farming. *Farm Economist*, I, 2, April, 1933.
2. ————: Management for milk production. *Manch. U. Bull.* 1.
3. ————: Value of hay in winter feeding. *Ibid.*

121. MIDLAND AGRICULTURAL COLLEGE

Profitability farming in Derbyshire.—There are approximately 60 farms mainly in Derbyshire on which financial records are kept. The records are analysed and the report sent to the farmer shows as far as possible what has actually happened financially on his farm during the year under review (1). The reports are followed up by a personal visit either by a member of this Department or in many instances by the Agricultural Organiser.

Management for milk production.—One year's work has been completed on the herd management scheme and further work is in progress. This investigation involves more detail than the financial accounts scheme and the report issued to the farmers is more comprehensive. Owing to incomplete data from eight farms records from ten farms only were used in the published report (2) which covers such problems as the efficiency of feeding and of labour utilization. The measurement of efficiency of grassland is determined in a theoretical adaptation of the starch equvalent formula. Some attention is also given to the effect of herd maintenance charges on cost of production.

Potato production and marketing.—The enquiry into potato production and marketing costs, commenced in February, 1932, has been continued. Approximately 400 growers co-operated during the first year and each received a detailed statement of his crop costs. Returns covering the second season of the investigation have been completed by over 300 growers and costs statements are in

the course of preparation. Three statistical bulletins, giving detailed analyses of the costs with comparative tables, and one interim report on the investigation have been issued (1, 2, 3).

Titles of papers issued during the year.

1. Jones, A.: Analysis of financial accounts. Derbyshire, 1931-33.
2. ————: Management for milk production.
3. ————: Early potato costs, 1932. Farmers' Bulletin No. 1.
4. ————: Potato production and marketing. Early potato costs in the Boston area.
5. ————: Maincrop potato costs, 1932. Farmers' Bulletin No. 2.
6. ————: Early potato costs, 1933. Farmers' Bulletin No. 5.

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122. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY

Poultry management study.—This investigation, which was begun in December, 1930, is now in its fourth year and has covered three annual accounting periods. It has been conducted in close collaboration with the West Midland and North Western Advisory Provinces throughout and was extended in its third year to include the Bristol Province also. Not only has it provided interesting and valuable material on the economics of commercial egg farming, but it has also proved an important experiment in the technique of co-ordinated investigations by advisory centres separately financed and independently administered. On this latter aspect of the work reference is invited to the comments given in the report for last year.

The investigation is concerned only with commercial egg farms and the combined results for the West Midland, North Western and Northern Provinces, which are now available for the year 1931-32, provide a complete economic analysis of eighty-nine separate enterprises. For the year 1932-33 for which the separate provincial results are now being brought together, approximately the same number of enterprises will be included, and it is hoped also to embody results of about twenty farms from the Bristol Province.

Originally undertaken to fill an obvious blank in the state of current knowledge of an important branch of livestock husbandry, the results of the investigation are coming to fruition at a time when they may be of maximum value to the industry through the work of the Reorganisation Commission for eggs and poultry set up under the Agricultural Marketing Act, 1931. The material collected and analysed in the course of the investigation represents the only considerable body of information on the economics of poultry farming prepared on a uniform and consistent basis to admit of comparative analysis. It is, of course, impossible to say whether this sample of approximately 40,000

birds distributed in about ninety separate enterpises is a representative sample of the make up of the commercial egg farming section of the whole poultry industry, but is fairly certain that it does cover the extremes in the range of profitability, and may claim to be regarded as an important and positive contribution to recent agricultural economic research.

In brief, the most striking features of the results obtained to date may be stated as :—

(*a*) The extraordinarily wide range of profits per bird achieved by individual producers. For example, in the year 1931-32 profits per laying bird ranged from 19s. 4d. (Profit) to 5s. 3d. (Loss). In the following year a similar range occurred but at a lower general level.

(*b*) The wide range in egg production per bird over the year in individual flocks. The over-all flock average of 154 eggs per bird represents a range in individual flocks from 86 to 217 eggs per layer.

(*c*) The relative steadiness of costs of production and the dominance of feeding costs on this side of the account.

(*d*) The decline in returns owing to the falling level of egg prices, and the consequent shrinkage in the poultry farmers' incomes, where the size of the flock remains approximately the same.

(*e*) The increase in the rate of mortality in commercial egg flocks. This rate has increased by 2 per cent. of the initial flock in each of the years during which the survey has been carried on.

Reports on the individual enterprises have been made to the collaborating farmers each year and indications are now appearing as to the extent to which recommendations have been carried into effect.

Miscellaneous.—Amongst other activities reference may be made to an examination of the agricultural aspects of the demand for labour in the county of Cumberland which was undertaken as part of an industrial survey of Cumberland and Furness. The report of this investigation has been published (1).

The problem of egg marketing in the North Eastern area has also been studied.

Title of paper issued during the year.

1. Dinsdale, D. H.: Agricultural employment. *Industrial survey of Cumberland and Furness*, 1933.

123. READING UNIVERSITY

Survey of the strawberry industry in Hampshire.—The final report of this survey (described in last year's report) has been published (5).

Agricultural survey of Middlesex.—A general agricultural survey of the county of Middlesex has been undertaken at the request of the County Agricultural Education Committee. All occupiers of land in the county who completed the annual return for the June Statistics in 1932 are being visited and as many survey schedules as possible are being taken. While this survey, like the others which have preceded it, is directed towards ascertaining the relative financial position of different systems of farming in the county, special attention is also being paid to (i) the construction of an economic geography of land utilization in the county; (ii) the construction of a comprehensive census of the agricultural population, which, it is hoped, will prove a useful addition to the study of London life and labour which is now in process; and (iii) the examination of the influence of the pressure of urban encroachment on the utilisation of land and the movement of land values in what is probably the most important suburban farming area in the world. It is also intended to follow up this general survey with a more intensive study of the horticultural industry in the county.

Cost accounts.—Complete cost accounts were kept on six farms having a total area of 2,226 acres. The types of farming were: one arable sheep farm, three mixed arable and milk selling farms, one retail milk-selling and poultry farm, and one cheese-making farm. Four of these farms have been included in this investigation since its commencement nine years ago. A report on one of them covering eight years accounts has been published (1).

Survey of farms producing peas for canning.—This was a survey of all the farms in the Province which supplied the Slough Canning Factory with peas for the 1932 season. There were only eleven growers concerned, nine in Buckinghamshire and two in Berkshire. In addition two growers in Oxfordshire sent peas to the Evesham factory. Altogether, approximately 100 acres were grown for canning between these thirteen growers. In the majority of cases 1932 was the first season for this crop to be grown. The information obtained was very scanty, particularly since most of the growers were disinterested in the crop as the contracts for the 1933 season had fallen through just when the survey was being conducted. The chief varieties grown were Lincoln, Prince of Wales and King Charles I. The seed was usually supplied by the factory. Yields varied considerably from 100 to 300 bushels per acre. The average price received for the 1932 crop was 3s. 6d. per bushel of 42 lb.

Incidence of diseases of live stock.—In co-operation with the advisory veterinary officer a tentative scheme has been prepared for the collection of statistics of such diseases of live stock as have been treated by veterinary surgeons, with the object of ascertaining the incidence of such diseases within the province and relating such incidence to the distribution of the live-stock population.

Financial accounts.—The policy of keeping financial accounts on farms selected statistically in those areas in which surveys have been conducted is being continued.

(i) A group of seventeen Blackmore Vale dairy farmers which has now kept accounts for two years. A report on the second year's results was circulated to each farmer. This report showed that when no charge was made for family labour all but one farm made a surplus. When, however, family labour was charged at current wages rates only seven farms showed profits, while ten showed losses. Each farmer was supplied with a comparative efficiency table in which his result was compared with the average results on all seventeen farms and also with the average of the four farms with highest profits. The farmers concerned are continuing the work for another year.

(ii) A group of fifty Hampshire strawberry growers. The cost and financial results for these growers were collected in respect of the 1933 crop, similar figures for the same growers in 1932 being already available. At the moment the analysis of these results has not been completed. It is hoped, however, to present a report on the results shortly.

In addition to the above two groups of accounts, a group of six dairy farmers in North Hampshire are co-operating as from last Michaelmas.

Titles of papers issued during the year.

1. Thomas, E., and Pringle, C.: A Dorset sheep and corn farm. *J. Min. Agric.*, **39**, 9, 814-827, December, 1932.
2. Pringle, C.: Slatted floor poultry house demonstration, 1930-32, Financial appendix. *Middlx. Agric. Educ. Sub-Cttee.* Paper No. 37, 1933.
3. Thomas, E.: Local surveys and their uses. *Agric. Prog.*, **10**, 17-21, 1933.
4. Pringle, C.: Developing poultry-keeping on a mixed farm. *Farm Economist*, **1**, 2, 28-30, April, 1933.
5. Thomas, E., and Bissett, G. B.: *Survey Studies.* 2. (*Final report*), *Bull.* 45, *Univ. Reading, Agric. Econ. Dept.*
6. Bissett, G. B., and Pringle, C.: Financial results of dairy farming in the Blackmore Vale, 1932-33. *Financial Accounts Studies*, 3.

124. SEALE-HAYNE AGRICULTURAL COLLEGE

Financial accounts.—The accounts of 91 farmers, covering 21,640 acres, were collected, analysed, and reported on during the year. The same groupings were used as in previous years, and the report sent to each co-operating farmer was on the usual lines.

This Department is now analysing the books, as distinct from the completed profit and loss account, of a greater proportion of farmers than a few years ago. This is the only method of obtaining accounts from the majority of farmers, whose business is too small to make farm accounting for income tax purposes necessary. This is probably truer of a province of small farms, like Devon and Cornwall, than it would be in most other parts of England.

There are indications that interest in book-keeping is considerably greater among farmers to-day than it was a few years ago, although it would not be true to say that an appreciation of the value of accounts for farm management purposes was the only inspiration. The response to a book-keeping course which is being conducted this winter in conjunction with the Devon organiser has been very enthusiastic. On the other hand, there are also signs that increased work, either on the farm (owing to a reduction in labour staffs, a tendency clearly indicated in the accounts in the last year or two) or in the farm house, has caused a few promising farmers to give up account keeping, or to spend less time on their books than is desirable.

Labour requirements.—The work on the investigation into the productive labour requirements of crops and stock in Devon and Cornwall is being prepared for publication.

Feeding stuffs investigation.—The first year of this investigation closed at the end of October, 1932. Complete records were available from 25 West Cornwall farmers and a report (10) was published. An attempt to induce the same farmers to keep the records for a second year was only partially successful, but 10 had almost completed a second year's sheets by Michaelmas.

This investigation started before the general research in milk production study was launched, and it was felt advisable to concentrate on one area, where the system of farming did not show much variation, rather than to include farms throughout the province. When the wider investigation was undertaken, this department approached some milk recording farmers, partly to come into line with other advisory economists, and partly to compare other districts in Devon and Cornwall with the West Cornwall results, and by Michaelmas, 1933, 18 were continuing the records which had been commenced at May 1st.

Broccoli Costs.—This investigation has been continued. Satisfactory records were completed by five Devon growers, but as they came from several parts of the county, and as the methods of disposal of the crop varied, very little general information on the economics of the crop throughout the county was obtained. The investigation was supplemented by a survey which included 36 West Cornwall farms. This study gave a much more complete picture of the area to which it referred than did the Devon study, and a report on Broccoli growing in West Cornwall (12) was published.

Titles of papers issued during the year.

1. MacGregor, J. J.: Livestock movements in the South-West. *J. Min. Agric.*, **40**, 5, 405, August, 1933.
2. Long, W. H., and MacGregor, J. J.: Pigs in the South-West. *Pig Breeders Ann.*, 1933.
3. Long, W. H., and Daniel, C.: Some factors affecting profitableness of Mid-Devon farms. *Farm Economist*, **1**, 2, 1933.
4. MacGregor, J. J.: Stock markets in North Devon and North Cornwall. *Ibid.*, **1**, 3, 1933.
5. Long, W. H.: Butter prices continue to fall. *Seale-Hayne Coll. Monthly Bull.*, No 31, November, 1932.
6. ————: The poultry industry and egg prices. *Ibid.*, No. 35, March, 1933.
7. ————: Pig keeping under the pig scheme. *Ibid.*, No. 40, August, 1933.
8. ————: Will beef prices improve? *Ibid.*, No. 41, September, 1933.

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9. Long, W. H., and Daniel, C.: Factors affecting profits and losses on South Devon Farms. October, 1932.
10. Long, W. H., and McCann, N. F.: A study of foods fed to livestock in West Cornwall, 1931-32. (Report No. 5.) March, 1933.
11. Long, W. H., and Daniel, C.: Financial accounts on certain Devon and Cornish farms, 1931-32. (Report No. 6.) June, 1933.
12. MacGregor, J. J.: Cost of growing broccoli in Devon and Cornwall, 1932-33. (Report No 7.) September, 1933.

125. WYE: SOUTH-EASTERN AGRICULTURE COLLEGE, LONDON UNIVERSITY

Farming costs.—This investigation has been continued on the same lines as in previous years. Sixteen reports have now been published and the evidence shows clearly that, however important marketing problems may be, there are numerous production problems still to be solved, many of which are closely associated with efficient marketing, and that the causes of the well-known differences in production costs, as well as in net financial results, cannot as a rule be found without a somewhat detailed analysis of the different cases.

Food recording scheme for dairy cows.—This scheme has been extended for a fourth year and a report on the results obtained during the first three years has now been published. It is emphasised that the first objective of this scheme is to enable the individual farmer to measure his own efficiency in the cowsheds, partly by comparing his results with those of other producers working under similar conditions and partly by comparing his own results from year to year.

Food recording scheme for pigs.—This scheme attempts to do for pigs what the above-mentioned scheme has done for dairy cows. A weekly report is prepared by each co-operating farmer as regards

kinds and quantities of foods consumed by the various classes of pigs, purchases and sales of pigs, births and deaths, litter weights, sale-weights and so on.

Strawberry investigation.—This investigation has been continued for a second year and sufficient information has now been obtained on the cost side to provide a foundation for the calculation of probable net returns, with different yields per acre and different selling prices.

Canning peas investigation.—During the past summer, information regarding the production costs of, and gross returns from, canning peas has been obtained from 26 growers in Kent and it is hoped to continue this enquiry for another season at least. The most striking feature of the returns for 1933 has been the extraordinary variation in the yield per acre, from only a few cwt. up to nearly 40 cwt. per acre.

Titles of papers issued during the year.

1. Wyllie, J.: Investigation into farming costs of production and financial costs. The cost of horse labour, 1926-27 to 1930-31. *S.E. Agric. Coll. Rep.*, 15, 65-95, 1932.
2. Wyllie, J., and Hewison, N. V.: Financial results on the College farms. Arable land crops, 1927 to 1932. *Ibid.*, 16, 74-121, 1933.
3. Knox, M. Allan: Food recording and cheaper milk production. (A report on three years' results from a food recording scheme for dairy cows.) *Ibid.*, 17, 1-39, 1933.
4. Wyllie, J.: Horticultural accounts. *J.S.E. Agric. Coll.*, 32, 24-37, July, 1933.
5. ————: The calculation of the annual cost of farm machinery and implements. *J. Roy. Agric. Soc. Eng.*, **93**, 45-67, 1932.
6. ————: An adventure in certified milk production. *J. Brit. Dairy Farmers' Assoc.*, **45**, 30-46, 1933.
7. ————: Efficiency in the cowsheds. *Ann. Rep. Central Council Milk Recording Socs.*, 35-37, 1932.
8. ————: Cost accounting in a symposium on recent progress in agricultural economics. *Agric. Prog.*, **10**, 21-24, 1933.
9. Knox, M. Allan: Cost per unit as a measure of efficiency. *J.S.E. Agric. Coll.*, 32, 38-41, July, 1933.

126. ABERDEEN: NORTH OF SCOTLAND COLLEGE OF AGRICULTURE

Financial accounts investigation.—The investigation into the relative profitableness of farming in Scotland was continued and 76 records were utilised for the analysis. These were grouped according to farming type. Group I contained farms where the organisation was built around feeding cattle mainly purchased as advanced stores, Group II those farms where breeding, rearing and feeding were practised, and Group III those farms mainly producing milk for the whole milk market.

Reports on these groups were prepared for limited circulation, and supplied to each farmer who assisted the scheme but were also

available to anyone interested in the work. These referred to the crop year 1931-32. The results of Group I showed an appreciable improvement as compared with the previous year owing to the better prices available for potatoes and oats. The results on the average showed a slight profit. Farms in Group II were less influenced by the price of potatoes and oats and on the average were less profitable than Group I, the average result being a slight loss. Group III farmers enjoyed a better financial return than those of any other group and on the average the returns were satisfactory. This was largely due to the organised milk market which the majority supplied.

The outstanding feature in all groups was the financial success of farmers who had a balanced organisation and utilised their various enterprises so as to obtain the maximum production from their available resources of land, labour, and capital.

Poultry investigation.—The financial results of poultry farms and enterprises were studied, and a report published on the results (3). It was found that on the average approximately 5s. per bird could be obtained where the poultry flock was properly attended.

Cost accounts.—Several farmers kept cost records for the department and these are made up so as to make available details regarding the cost of production of typical crops in the area.

Milk costs.—The cost of production of winter milk was investigated by the enterprise cost method and the figure published.

Titles of papers issued during the year.

1. Imper, A. D.: Group reports on financial accounts. Circulated privately.
2. ————: The cost of production of winter milk. *Scott. J. Agric.*, **15**, 4, 437-441, 1932.
3. ————: Poultry keeping costs and returns. *Aberdeen Press and J.*, 28, 29, Nov., 1932.

127. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE

Farm accounts investigation.—The study of the three groups of farms is being continued, the number of accounts analysed continuing to show a steady increase. The analysis of the records for the year 1931-32 (covering the 1931 crop) shows a contrast between the arable farm of the East Lothian type and the arable and semi-arable sheep farms of the Border counties (1, 2).

An analysis of the financial results of 16 East of Scotland arable farms for the years 1928-32 gave the following average figures:—1928-29, £61 profit; 1929-30, £54 loss; 1930-31, £20 loss; and 1931-32, £360 profit. The substantial amelioration in the fortunes of these farms was mainly a reflection of the exceptional profitableness of the 1931 potato crop rather than an indication of a general all-round improvement.

The financial results of a group of arable sheep farms for the years 1929-32 gave the following average figures:—1929-30, £230 profit; 1930-31, £201 loss; and 1931-32, £369 loss. The sharp decline in sheep prices which commenced in the autumn of 1931 materially affected the financial returns of these farms. There is little doubt however that the lowest point was reached in the year 1931-32 and it is fully expected that the year 1932-33 will show an improvement.

A similar fall in profits was shown by the small group of six Border high-ground semi-arable sheep farms, the average financial results of which were as follows:—1929-30, £828 profit; 1930-31, £288 profit; and 1931-32, £39 loss.

Smallholdings accounts investigation.—The work undertaken on smallholdings in the previous year was considerably enlarged, as it was felt that ample scope exists for an extension of useful advisory work in this field, although the effect of this will not be seen until next year. During 1931-32, the accounts of eight smallholdings were studied, all but two of which were demonstration holdings in receipt of a monetary grant from the College, four of them being dairy holdings, and four arable holdings. As in the previous year, the dairy holdings showed a higher profit than the arable holdings (£3 7s. 5d. per acre as against £2 17s. 4d.), but both groups showed a decline in their fortunes, the profit per holding on the dairy holdings falling from £178 to £136, and that on the arable holdings from £130 to £114. It is noted that if a wage of 35s. per week for the unpaid work of the smallholder and his wife be charged in the accounts, and 5 per cent. interest on capital invested, the holdings would on an average still show a surplus, though a very small one, of £14 4s. 6d. per holding on the dairy holdings and £1 2s. 6d. on the arable holdings (3, 4). During the ensuing year the accounts investigation work is being extended to embrace a small group of specialist poultry farmers.

Potato information service.—This service, which was inaugurated in November, 1932, is carried out with the assistance of the County Organisers in the College area. Briefly, the object aimed at was to obtain in the late autumn from a representative sample of farms in the East of Scotland up-to-date information regarding the acreage of potatoes planted and tonnage lifted, with subsequent information concerning the disposal of the crop and stocks on hand at some convenient point of time early in spring. In the first instance over 500 circulars were dispatched to growers. As a result, it was found possible to issue with the utmost dispatch to co-operating farmers, two reports relating to the 1932 crop—one late in November and one in mid-March—in which the position revealed by the farmers' returns was co-ordinated with the general potato position and prospects for the whole country.

The 1932 crop proved to be very abundant, the average yield obtained by the 274 reporting farms working out at 8 tons 17½ cwt.

as compared with 6 tons 7 cwt. in the previous year. The heavy crop was very slow in moving into consumption, the bulk of it realising low prices far below the cost of production, whilst large quantities were fed to stock. Even so, as was predicted in the spring report, things did not prove to be so bad as in the disastrous season 1929-30 (5, 6).

Both these reports were well received, and it is hoped to continue and amplify this work in connection with the 1933 crop.

Titles of papers issued during the year.

1. Ellis, P. G., and Witney, D.: Reports on the financial results of 30 East of Scotland arable farms in 1931-32.
2. ————: Reports on the financial results of 21 Border semi-arable sheep farms and 6 Border high-ground sheep farms in 1931-32.
3. Witney, D.: Reports on the financial results of 8 smallholdings in 1931-32.
4. ————: Report on the financial results of 13 smallholdings for 1932-33.
5. ————: Potato Information Service November Report on 1932 Crop.
6. ————: Potato Information Service Spring Report on 1932 Crop.

All circulated privately.

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128. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE

Financial accounts investigation.—This has been continued on the lines of previous years and the area covered by representative farm accounts is being extended. Lectures to agricultural discussion societies on the results of the investigation appear to have been appreciated and have resulted in voluntary requests for participation. The numbers of accounting farms in the " older " areas will not permit of any great increase if other districts are to be covered by the Scheme.

Accounts analysed during the year illustrated the unremunerative nature of the non-dairy general farms. The depressed markets for fat cattle, hay and potatoes left their mark on the farm income where these commodities were the principal cash crops. Dairy holdings, particularly those farming on intensive lines, maintained their superiority at a slightly lower level than in the previous year. Well-managed dairy and poultry holdings continued to be the most profitable.

Poultry accounting investigation.—This section of the work increased in importance but it is not intended to extend beyond the numbers now attained, except to meet specific requests for co-operation.

Cost of feeding in milk production.—A study of feeding costs on a small number of farms was completed during the year; 9 farms having co-operated for the winter period and 6 for a complete year. Interim results were circulated and final conclusions are in course of preparation.

Titles of papers issued during the year.

1. Gilchrist, J. A.: Summary statement of farm profitableness, 1932-33. Circulated privately.
2. ————: Reports on eight groups of S.W. Scotland farms, 1932-33. Circulated privately.
3. ————: Winter feeding costs on dairy farms. Circulated privately.
4. ————: Financial returns of seven poultry farms. Circulated privately.
5. ————: Milk production feeding costs, 1932-33. *Scott. Farmer*, January, 1934.

GRASSLAND

129. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES (WELSH PLANT BREEDING STATION)

Seeds mixtures.—The work on seeds mixtures has been largely concerned with questions relating to competition between the different strains of one and the same species in simple mixtures. A large number of trials have been conducted in the counties, and it has been found that there is little difficulty in establishing the indigenous strain of cocksfoot and of perennial rye-grass in well balanced mixtures, but that timothy presents rather special difficulties, even the commercial strains being difficult to establish in competitive mixtures.

The improvement of rough and hill grazings.—Much of the work on waste grazings is conducted in the lowlands, and the methods that are being perfected in connection with the hill work are being found to be applicable to the lowlands also. Much attention is being given to date of sowing, and to date of application of manures, while the factors which seem to determine the successful establishment of white clover, crested dogstail and perennial rye-grass are subjects of special study. Experiments are in progress to test the influence of alsike clover on the spread of the nodule organism and, therefore, upon the more successful establishment of white clover on areas where the bacterium is deficient.

Influence of manures on natural vegetation.—Experiments have now been started to test on a larger scale the influence of manures on the natural vegetation without the addition of seeds of any kind. The aim chiefly being to study the influence of manures on palatability, and on the competitive relationship between the more valuable and the least valuable species.

Detailed researches are also in progress relative to such important plants as heather and heath rush.

III

OTHER INVESTIGATIONS

130. IMPROVED MANAGEMENT OF GRASSLAND

(*a*) Welsh Plant Breeding Station, Aberystwyth

This work, done in co-operation with Professor Fagan, consists for the most part of chemical researches conducted in connection with a number of the grassland experiments laid down by the Station. At present an exploration is being made of the influence soil and climate and methods of management (including manuring) have on the chemical composition of individual species and strains. A report (1) has been issued relative to the differences which show themselves when grasses are grown in drills, in pure plots and in mixtures. The grasses in drills were more luxuriant than in pure plots or in mixtures, with a higher proportion of stem to leaf. The nitrogen content of the stem was higher in the grasses grown in drills, with the result that the drill herbage as a whole (leaf and stem) was richer in nitrogen than the herbage from either pure plots or mixtures, and the same was true in respect of potash.

Pedigree strains of the different grasses have been grown at a number of centres at different elevations and with different manurial treatments. A mass of chemical data has been collected during the present season, and a report will be issued at an early date. Until all the figures have been brought together and critically examined, it is not possible to indicate the general results of these extensive and interesting trials.

The investigations relative to the recovery of nitrogen in pastures subjected to applications of nitrogenous manures are being continued and extended.

Title of paper issued during the year.

1. Fagan, T. W., and Milton, W. E. J.: A comparison of the nitrogen and mineral content of the pasture, hay and aftermath of four species of grasses grown in a mixture, pure plots and pure drills. *Welsh J. Agric.*, **9**, 93-109, January, 1933.

(*b*) Bristol University

During the year under review several of the grassland investigations outlined in the previous report have been concluded. Amongst these may be mentioned the following :—

(i) A comparison between the extensive and intensive systems of grassland management.

(ii) The response of Wiltshire Down pastures to intensive treatment.

(iii) The seasonal variation in the composition of natural pastures in the West of England.

(iv) The effect of simple manurial systems on the nutritive value of pastures.

(v) The nutritive value of winter grass.

(vi) The iodine content of herbage in the West of England.

(vii) Nitrogen metabolism in clovers.

A full report on the work in connection with grassland problems is now in the course of preparation and it is hoped that this report will be published during the present year.

The following investigations are still in progress :—

(i) A comparison of the yield and nutritive value of fodder obtained by the practices of grazing, haymaking and silage making.

(ii) The effect of folded poultry on the chemical composition of the soil and herbage.

(iii) The Teart grassland of Somerset.

In connection with the Teart investigation, it was not possible to proceed with the scheme of experiments mentioned in the previous report, on account of the prolonged drought during the summer and autumn of 1933. Under the climatic conditions prevailing no " teartness " developed, in fact, farmers in the Teart area reported that fields which were normally teart had provided the most valuable grazing when the other fields on the farm were burnt up.

The experimental procedure outlined in the previous report will be put into operation during the coming grazing season if there are any indications of the development of " teartness ".

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131. PRODUCTION OF SEED POTATOES ON A COMMERCIAL SCALE IN NORTH WALES

Bangor : University College of North Wales

The number of centres engaged in the scheme during 1933 was thirty, at all of which stocks of three varieties of potatoes, after inspection during the growing season, were found to contain not more than ·5 per cent. of plants showing symptoms of virus infection. Fourteen of these centres have already been approved as suitable for the production of healthy stocks of certified standards, and the remainder were in the first or second year of a test period extending over three growing seasons.

In comparative yield trials carried out on the College Farm with Welsh seed from approved centres and stock seed from Scotland the results were very even in the case of the varieties Sharpe's Express, Great Scot and Arran Banner, but in the variety Kerr's Pink the Welsh seed gave a significantly better yield than the Scotch seed.

A stage in the progress of the work was marked by the formation, in the early summer, of a registered society of growers, the main function of which is to encourage the production of certified stocks and develop the commercial aspect of the scheme. In order to accelerate and increase the scale of production, proposals for the

extension of the scheme have been adopted by the society. These include the introduction of about 50 new members, modification in the standards of certification and the employment of temporary inspectors. An important feature of the new proposals is the continuance of a number of centres to be known as " stock seed centres ", at which the stocks will be maintained at the original high standard of less than ·5 per cent. virus diseases.

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132. DISTRIBUTION OF SULPHUR DIOXIDE IN THE VARIOUS TISSUES OF PRESERVED FRUITS AND JAM

Bristol University

A comprehensive scheme of research was commenced to ascertain the distribution of SO_2 in the main portions of fruit preserved by the cold SO_2 process. Differences between the total amount present in skins, stones, and flesh of plums were established but in the case of soft fruits, where the manipulation required to separate the seeds and flesh was more complicated, similar results were not obtained. Complications due to the presence of " fixed " and " free " forms of SO_2 were recognised, and a method evolved whereby these two forms could be separated.

The salient features which have been established during the course of the work, are as follows :—

(i) In experiments with preserved plums, the strength of the SO_2 solution was found to be an important factor governing the distribution of SO_2 between the various tissues.

(ii) In determining the SO_2 content of seeds and flesh of preserved strawberries, the loss of SO_2 occurring during manipulation was greater with fruits preserved in stronger SO_2 solutions.

(iii) The estimation of " free " SO_2 by the usual iodine method was found to be completely unreliable when applied to fruit pulp.

(iv) Distillation of the pulp at reduced pressure and temperature in a stream of CO_2 was satisfactory for the estimation of " free " SO_2.

(v) The length of time of distillation affects the amount of SO_2 recovered as " free " by the distillation method.

(vi) The amount and proportion of " fixed " SO_2 varied with the strength of the preserving solution which had been employed.

133. *SPARTINA TOWNSENDII* (RICE GRASS)

East Anglian Institute of Agriculture, Chelmsford

It has been ascertained that *Spartina Townsendii* can be successfully established on mud and clay, in a large variety of situations, from high water mark of spring tides downwards to a level about 10 feet below that line. Within this belt, however, there have been cases of partial or complete failure. The partial failures were almost certainly due to the ravages of the sea-slug (periwinkle). The complete failures have not been fully accounted for, but the possible causes have been narrowed down to conditions set up by the interplay of tidal currents. It appears to be unlikely that tidal velocity alone, within an as yet undetermined maximum, is sufficient to prevent establishment and growth. It has been shown that a velocity of approximately one foot per second can be withstood.

Preliminary experiments to determine the best time to plant indicate that autumn and early winter planting may be best, especially under comparatively adverse conditions.

Germination tests with seeds were continued and again confirmed the finding that seed kept under ordinary conditions in storage has a period of vitality of about 15 weeks. It has been demonstrated, however, that this period may be prolonged to at least about 40 weeks by storage under anaerobic conditions and at low temperatures.

Supplies of cuttings and seeds have been sent by request to Canada, West Indies, Central America, South Africa, and North Africa. A report has been received from the Riverina District, New South Wales, to the effect that the cuttings sent in 1930 and planted on salt lands, under irrigation, continue to grow satisfactorily, providing fodder for stock. They are being multiplied by planting out the offsets. The consignment sent to India in 1931 for a similar purpose has proved a failure.

In Holland the Dutch have continued to elaborate their technique for the employment of *Spartina* as an aid to land reclamation from the sea, with very striking and spectacular results. In Germany also the grass is being used for land reclamation in conjunction with a unique system of light brushwood dams. The latter are designed to regulate the flow of the tide in such a way as to give an even deposition of silt.

Title of papers issued during the year.

Bryce, J.: The economic possibilities of rice grass. *J. Roy. Soc. Arts*, 81, 4176, Dec. 2, 1932.

134. TREATMENT OF "BLACKHEAD" IN TURKEYS

HARPER ADAMS AGRICULTURAL COLLEGE

In order to carry out experiments upon the value of Neo-salvarsan as a curative agent for entero-hepatatis, the so-called "Blackhead" disease of turkeys, 220 birds were purchased at the beginning of June, 1933. It was hoped to conduct this experiment under exactly similar conditions to those existent upon most poultry farms in this country, and to treat at least 100 birds with Neo-salvarsan, leaving a similar number of birds to act as controls. A portion of land was selected for the experiment, which had been used for the raising of turkeys for several years, and where some of the birds which had occupied the land had always suffered from Blackhead.

Unfortunately severe losses occurred in both groups early in the course of the experiment due to an attack of infectious catarrh. The outbreak proved difficult to control on account of the exceptionally hot weather at the time and the impossibility of ensuring an even temperature in the brooding houses. The mortality finally reached the high figure of 72 per cent. It was then decided to use the remaining birds for experimental purposes in connection with the artificial infection of Blackhead by feeding fresh liver lesions, and in the treatment of artificially produced disease by injections of Neo-salvarsan.

Arrangements were made with a number of turkey owners in the area for experiments to be conducted on their farms upon the treatment of Blackhead under natural conditions with Neo-salvarsan. Eight turkey breeders co-operated in this work and nine experimental groups were arranged upon farms under various methods of management. The nine experimental groups were made up of units containing various numbers of turkeys ranging between 12 and 30 in each group with an average number of 20 birds. The total number of birds in all the groups was 181.

In every case the following procedure was adopted before the experimental treatment was commenced:—

(i) "Blackhead" was diagnosed in one or more birds in the flock by means of post-mortem and microscopical examinations.

(ii) The flock was examined, the birds were weighed, and observations made upon their condition.

(iii) The turkeys selected for treatment were, in all cases, birds actually showing signs of the disease and those in a poorer condition than the control birds.

(iv) The treated birds were ringed.

The following conclusions were formed from these investigations:

(i) That Neo-salvarsan in doses of 0·005 grammes per lb. live body weight is a valuable drug in the treatment of "Blackhead" in turkeys under natural conditions, and provided the

disease is not generalised with involvement of the lung tissue, a cure may be expected in the majority of birds so treated.

(ii) That in artificially infected birds the disease does not respond to treatment so readily.

Comparisons with previous experimental treatment with tryparsamide as a curative agent for "Blackhead" carried out at this centre, tended to show that this drug was more effective than Neo-salvarsan.

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135. AERIAL TOW-NETTING OF INSECTS

Department of Zoology and Oceanography, University College, Hull

Very successful series of collections were made at Hull at altitudes varying from 150 to 1,500 feet by means of nets towed by kites. A summary of the insects caught in a total flying time of 76 hours showed a predomination of the families *Aphididae*, *Acalypterae* and *Mycetophilidea* in that order. Altogether 26 families were represented in a "bag" of 592 insects.

Mr. Milne has greatly improved the technique of operating the kites and nets at different altitudes, inventing a most ingenious mechanism for opening and closing the nets. Catches were also made on the coasts of Suffolk and Kent which afforded an interesting comparison with those mentioned above. The Coastal operations, however, were qualified by the fact that winds from the Continent were not as favourable as had been anticipated.

Mr. Milne has made a special study of the *Aphididae*.

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136. BACTERIAL DISEASES OF PLANTS

Imperial College of Science and Technology

These investigations included a study of sixteen suspected cases submitted for diagnosis, and for comparison with some of these diseased material was obtained from two other sources. Of these eighteen cases, fourteen gave successful isolations of pathogenic bacteria, the organism being identified with certainty in seven instances. In three cases the identification was doubtful, and in two cases there has been doubt as to the bacterial nature of the disease. In one case, a disease of figs in which the symptoms were strongly suggestive of bacterial attack, it was clearly shown that the trouble was physiological. Miss Lacey has continued her investigation of the green-fluorescent bacteria and has attempted to discover the cause of the variation in pathogenicity within the group. Researches have also been carried on as to the cause of marsh-spot in peas; diseased

and healthy seed have been grown in soil collected from a healthy and from disease-producing areas, but only healthy crops appeared. No conclusions can be drawn at present from these results; experiments on similar lines on a larger scale are called for.

Miss Lacey has also continued an investigation of crown gall disease on Manetti stocks. The results of this so far have not enabled a distinction to be drawn between a pathogenic condition and healthy callus overgrowth.

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137. FRUIT BREEDING EXPERIMENTS

John Innes Horticultural Institution

During the past year, work upon the apple has presented no special features, but chromosome counts have been made on the root tips of seedlings derived from triploid × triploid or triploid × diploid varieties. The majority of these seedlings were aneuploids of weakly constitution. A few diploids were found, and these were much more vigorous than the rest and had a high percentage of good pollen.

Systematic work was also begun on pears. Mr. Crane is determining pollen behaviour and self- and cross-incompatibility, while Dr. Moffett is studying the cytological constitution. Of 13 varieties examined four proved to be triploids, these being the well known varieties Buerré Diel, Buerré d'Amanlis, Catillac and Pitmaston Duchess. Chromosome behaviour at meiosis in the triploid varieties is irregular, resulting in a very low percentage of good pollen. The chromosome behaviour indicates that the cultivated pears, like the apples, are complex polyploids. A preliminary account of the cytology of the pears is in the press.

As regards the Rubi, a cytological study was made of the Veitchberry ($2n = 28$) to determine the cause of its low pollen fertility. It was found that many of the chromosomes failed to pair, and irregular gametes resulted. An examination of root tips of seedlings from the Veitchberry showed that they were all orthoploids, with 28 chromosomes. Aneuploid gametes must have failed to function. An examination of the pollen of seedlings derived from a plant with very little good pollen showed that they fell into two classes, one with very little good pollen, like the parent, and the other with a high percentage of good pollen, 60-80 per cent. The work is incomplete and is being continued. Cytological studies were also made in diploid, triploid and tetraploid raspberries, and on crosses between the Veitchberry and other Rubi.

Chromosome numbers were determined in several forms of Prunus commonly used as rootstocks for graftng varieties of Plum and

allied fruits. Six of these were found to be hexeploids (2n = 48) and one, St. Julien " B ", a pentaploid with 2n = 40 chromosomes. The chromosome constitution may have a bearing upon incompatibility and bad unions between stock and scion, the immediate factor being perhaps too great a differentiation in the size of the cells.

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138. BLACKENING OF POTATOES AFTER COOKING

London University : King's College of Household and Social Science

The work described in the Report for 1930-31 has been continued. More evidence has been obtained in support of the theories that a compound of iron is involved in the oxidation which gives rise to blackening after cooking; and that blackening after cooking is quite distinct from the darkening which takes place by enzymic oxidation in raw potato.

Growing tests have been undertaken at Northwood, Middlesex, with the hope of obtaining some information as to the absorption of iron by potatoes from the soil. Eight tubers of each of 45 varieties were planted in clay soil and were treated in various ways with iron compounds, but so far no positive results have been obtained from these experiments. Information as to the occurrence of blackening and the conditions under which such potatoes have been grown and stored is being collected.

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139. BLOW-FLIES OF SHEEP

London School of Hygiene and Tropical Medicine

During the past year an endeavour was made to infect living mice and guinea pigs with blow-fly larvae. It was unsuccessful with guinea pigs, but by using great care mice were infected. The character of the result, however, was such as to shew that the natural infection of sheep involved factors incapable of investigation on small mammals.

An attempt was then made to rear larvae on wool, alone and mixed with urine and dung. These attempts were unsuccessful, and suggested that the " blown " wool contained some food material absent from healthy wool. Subsequently an Australian worker stated that the larvae on a struck sheep feed on a serous exudate from the skin.

A study was made of the growth of blow-fly larvae on blood and serum. Under aseptic conditions these form an inadequate food for the larvae, any bacterial infection at once enabling the larvae

to grow rapidly, evidently by synthesising some lacking growth factor.

It was shown that sterile blood lacked at least three different vitamins,

(i) A heat labile substance, probably identical with vitamin B_1, present in water extracts of yeast;

(ii) One or more heat stable substances present in autoclaved yeast extracts; and

(iii) A substance which cannot be extracted by water or alcohol from yeast, but is present in water extracts of yeast autolysate.

It was also shown that factor (i) can be replaced by Peters' highly purified preparations of vitamin B_1 and that the amount required of different preparations was proportioned to its content of B_1 as judged by antineuritic activity in pigeons.

The whole work is theoretically important as a contribution to insect physiology, and the facts discovered will probably be found to be required in any investigation of the conditions necessary for the striking of sheep.

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140. RESEARCH IN ECONOMIC ORNITHOLOGY

Department of Zoology and Comparative Anatomy,
Oxford University

Weekly counts of the birds present on an area of about 120 acres of a farm at Sandford-on-Thames were made in the two winter terms. In the summer term a complete census of the breeding population on the whole farm of 296 acres was carried out.

The numbers of birds caught and ringed during the winter 1932-33 showed a great decrease at all 3 trapping stations compared with 1931-32 and an even greater decrease when compared with 1930-31. This decrease was mainly due to absence of starlings but was participated in by all species except house sparrows. A similar decline from a high figure in 1927-28 to a very low figure in 1929-30 was shown at the only trapping station then in existence. The figures point strongly to a 3-year cycle in the local bird population.

In April assistance was given to the census of rookeries in Somersetshire organised by Mr. B. W. Tucker, and in May and June to the census of breeding redshanks in the Upper Thames Valley arranged by the Oxford Ornithological Society, which was completed. During the winter further observations were made on the rook roosts in the Oxford district and the starling roosts were also located and their ranges delimited in connection with the enquiry by Mr. B. J. Marples.

Titles of papers issued during the year.

1. Alexander, W. B.: A census of house martins: Are their numbers decreasing? *J. Min. Agric.*, **40**, 1, 8-12, 1933.
2. ————: The rook population of the Upper Thames region. *J. Animal Ecol.*, **2**, 1, 24-35, 1933.

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141. FLUCTUATIONS IN NUMBERS AND DISEASES OF WILD RODENTS

Department of Zoology and Comparative Anatomy, Oxford University

A number of field visits to North Wales and Scotland have been carried out, as a result of which the periodic epidemic which attacks voles every four years was, for the first time, definitely worked out. The field intelligence system enabled the periodic abundance to be studied when expected; live voles were shipped to London during the epidemic, but some of these died and were examined by Dr. Findlay at the Wellcome Institute, who discovered a toxoplasma in the brains. The disease was not transmissible to ordinary laboratory animals, but could be successfully inoculated into voles bred at Oxford. Dr. Findlay has proved voles to be susceptible to "louping ill" from sheep, but the natural epidemic mentioned above was definitely not "louping ill," nor has the tick, *Ixodes ricinus*, so far been obtained from voles.

A preliminary try-out of a method of comparing mole numbers from year to year was made in two transects from railway-trains, between Oxford and Chester, and Oxford and Norwich. Another census method to give absolute densities of moles per acre will be carried out.

Data have also been collected, by correspondence and visits, on fluctuations and disease among hares and rabbits, squirrels, and other wild mammals.

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142. BREEDING OF OATS RESISTANT TO FRIT-FLY

School of Rural Economy, Oxford University

The season was admirable for sowing and early growth, but the continuous summer drought rapidly produced a slowing-down of growth, and the purple colouration of stem and blade, characteristic of this type of environmental condition, began to develop during the first week of June; this was not followed by any considerable total loss of plant, but showed its effect in limited tillering and poor panicle production, many plants failing to mature

their seed. Slight rain about shooting time, which occurred nine days earlier than last year, induced top growth, the lower foliage being dead at this time and maturation was slow and poor. The rapidity of early growth made it impossible to complete the stem analysis of approximately one-sixth of the crop, and this section will have to be sorted on general characters, tillering capacity and seed quality only.

A certain amount of stem damage resulted from the attack of *Tarsonemus spirifex*, a mite which sometimes increases rapidly in hot, dry summers.

In the standard plots the varieties Victory, Star, King, Spet and Summer (Hede being omitted this year both in standard and crossed form, owing to its excessive tillering habit) were distributed over the cage in 21 blocks, the average number of plants per variety used for determination of degree of infestation being 579.

The extent of attack was comparatively severe again this year, and the minimum shade temperature during the growth period between the one-leaf and the four-leaf stages was 45°F., which still suggests that a more detailed investigation into the relation between the degree of freedom from attack and temperature at this period growth might be productive.

The relative positions of resistant and susceptible parents are still maintained, the differences always being significant in spite of heterogenity of attack.

A considerable portion of the available cage space was devoted to the Spet × Star and Spet × King F_8 progenies, which were set out in quantity for the third year in succession. Analysis of a considerable population showed that resistance to attack was inherited, and could be combined with seed quality, standing power and earliness, to some degree.

The intermediate generations were carried on one stage further.

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143. CONTROL OF APPLE MILDEW

School of Rural Economy, Oxford

The method by which control of apple mildew may be attempted has been described. This consists in preventing the invasion of buds by mycelium. As the disease overwinters only in buds thus invaded, it was thought that the prevention of this by application of fungicides would provide a satisfactory and a practical method of eradication. The period during which fungicides could be applied effectively was observed by examination of newly formed axillary buds in the laboratory and was found to be while the gap left by bud-scales at the apices of buds still remained. This gap allowed access to mycelium situated on the stem for as long as the enclosing

bud-scales permitted, which was usually during June. This knowledge was applied in preliminary spraying trials, as well as in field-scale plots with success by spraying during the critical stage when patches of mildew, freshly established on the stem, endangered the buds.

A contrast is made between the methods employed for the control of Scab, *Venturia inaequalis* and of Mildew, and the relative unimportance of secondary infection in the latter case is pointed out. Mildew arises from and is to a large extent confined to infections endemically established in the tree, whereas scab may arise from a small restricted area and yet may become very serious any season when conditions are favourable for its spread. In the case of scab, therefore, secondary infection, and that of later origin, requires the greatest attention from the point of view of control. With mildew, secondary infection is not only seasonally sporadic, often being completely absent, but it is far less infectious. It becomes endemic, and its eradication from shoots and spurs on which it harbours in the form of mycelium within buds is the major consideration.

The control of mildew has been estimated by counts taken of overwintering infections on sprayed and control trees, and is presented as a percentage. In preliminary trials " colloidal " sulphur produced 88 per cent. decrease in the number of overwintering infections and a non-proprietary spray fluid produced a decrease of 86 per cent. At the recommended strength neither brand of " colloidal " sulphur was as effective, reducing mildew by 64 per cent. and by 35 per cent. respectively. Sulphur used as a " dust " reduced the disease by 18 per cent. The results obtained the following year were not as striking and the reason for this has been suggested. The results from a spray fluid containing washing soda and sulphur-casein were 49 per cent. on Lane's Prince Albert and 67 per cent. on Stirling Castle while sulphur-casein alone reduced the disease by 50 per cent.

As for the field-scale trials during 1930-31, 1931-32, and 1932-33, these demonstrated again the effectiveness of sulphur-casein, especially on trees in normal vigorous growth. The percentage decrease varied greatly according to the locality and the conditions appertaining to each. Inasmuch as the poor results at Malvern Wells were inconsistent with the weather conditions during 1930-31 an explanation that can be reasonably offered is that the trees lacked vigour and were very badly riddled with mildew. The stimulating effect of spraying actually brought dormant infections on older wood to light, so that the number of infections on sprayed trees increased. This occurred again after the next season's spraying to a less marked degree. The best control by sulphur-casein was obtained on Bramley Seedling trees at Mathon during 1930-31 and during the following year. Here not only were overwintering infections decreased but many fresh bud-infections which would

have been contracted secondarily, were prevented. Compared with control trees there was an apparent decrease of 131 per cent. and 319 per cent. respectively during each of these seasons. The control at Cheltenham and at Sedgeberrow during 1930-31 was 35 per cent. and 46 per cent. respectively. The 1933 counts demonstrated the accuracy of results during the previous years for no spray was applied during 1932 and the relations between sprayed and control trees remained unchanged. Sulphur sludge was substituted for sulphur-casein during 1930-31 at Sedgeberrow and at Malvern Wells with definite advantage. This was probably due to the additional sulphur applied.

Sulphur " dust " produced satisfactory results only at Malvern Wells and was definitely far less efficient at the three other localities. The control effected at Malvern Wells was due to ideal conditions which are essential to success if a " dust " is used. Sulphur-resin proved to be no better than Sulphur-casein, nor were the non-sulphur spray fluids namely, Cotton Seed Oil emulsion and Mustard Oil emulsion. The former proved to be the better of the two. Lime sulphur proved to be efficient against mildew but the damage was severe and entirely ruled out its use again under similar conditions.

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144. INVESTIGATION OF SOIL PROFILES IN COTSWOLD AND OTHER AREAS

School of Rural Economy, Oxford University

A representative area of the Cotswolds has been surveyed to determine the various pedological types existing, and to describe their morphology and general distribution. The pedological characteristics of the occurring soil types, the geography, climate and parent material of the region, have been studied, as have also the morphology, vegetation and distribution of types, etc.

The soil types recognised are :—Rendzinas—humus carbonate soils—residual or red and brown calcareous soils—brown forest soils—brown earths—intermediate and transitional soils—meadow soils and skeletal soils.

The use of such data may assist in the naming of some very representative Cotswold series. In addition, and for purposes of comparison, five monoliths were collected from Dartmoor representative of natural soil types.

145. EXPERIMENTS ON POULTRY MANURE

Rothamsted Experimental Station

Since dried poultry manure must be considered both as a potential source of nitrogen and phosphorus and may in addition have properties not possessed by inorganic salts, it was decided to carry out field trials on as wide a basis as possible. The general scheme of the experiments was therefore to test the effects of dried poultry manure in the presence and in the absence of equivalent amounts of inorganic nitrogen and phosphate. This gave the direct comparison of poultry manure against equivalent sulphate of ammonia, but it also made it possible to ascertain whether the response to poultry manure remained the same in the presence of sulphate of ammonia as in its absence. Similarly it was possible to find out where the effect of poultry manure might more properly be ascribed to its phosphate than to its nitrogen. It allowed tests of the possibility that the effect of poultry manure might even be different in type from those of inorganic fertilisers. Finally in cases of apparent equality between poultry manure and sulphate of ammonia the method could show whether or not this was due to the inability of the crop to respond to different amounts of available nitrogen.

The results obtained generally showed poultry manure in a favourable light, particularly with regard to market garden crops, and the experiments are being carried on for a further year.

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146. TRIALS OF HARDY FRUITS FOR COMMERCIAL PURPOSES

Royal Horticultural Society and Ministry of Agriculture

The season has been marked by the variable results obtained with fruits under trial at the central station, Royal Horticultural Society's Gardens, Wisley, and at the sub-stations established in different fruit-growing districts, due in the main to severe frost during April and the unusually dry summer. In the trial grounds at Wisley where the blossoming of all the top fruits coincided with very low temperatures, the effect of frost on the cropping of varieties of most kinds of hardy fruits is recorded. Generally, only those varieties that blossom late, or have a long period of blossoming, carried good crops. An exception is the " Czar " plum the blossoms of which variety appear to possess some degree of frost resistance. Further evidence of the cropping and behaviour of selected new varieties of currants, gooseberries, raspberries, and apples when grown in the different soils and conditions of sub-stations is available, and also the suitability of varieties of " soft " fruits to meet the requirements of the canning industry.

Titles of papers issued during the year.

1. Rawes, A. N.: Trials of hardy fruits for commercial purposes. Strawberries at Wisley. *Roy. Hort. Soc. J.*, 58, 1, 1933.
2. ————: Fruit trials at Wisley. Some new apples. *Ibid.*, 58, 2, 1933.
3. ————: The testing of new varieties of fruit at Wisley and its substations. *Rep. Cherry and Soft Fruit Show*, July, 1933. Kent Branch, N.F.U.

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147. PLANT BREEDING WORK ON BROCCOLI

Seale-Hayne Agricultural College

In order to be in close contact with the problems relating to strain which confront broccoli growers and to provide for the local testing of pedigree stocks, ten trial centres have been established throughout the Province in addition to the main area at the College. Over 150 selfed and cross-pollinated stocks have been produced and these have been tested beside the commercial stocks of Roscoff broccoli. The more widely grown d'Angers, Italian and Cornish varieties have also been included in these trials.

The following economic characters of broccoli have been found to have a genetical basis :—

(i) *Vigour.*—Certain pedigree stocks and commercial stocks selected in highly fertile areas failed markedly when grown on second quality land; whilst other pedigree stocks (notably S75) showed a remarkably high cropping capacity on such land, and when subjected to excessively late planting. Commercial d'Angers varieties proved superior to commercial Roscoff varieties in respect of mean vigour. The mean vigour of the strain is of great importance where broccoli growing is extended to new areas and under conditions of rotational cropping such as obtain in market gardens.

(ii) *Percentage of first grade heads.*—The quality characters of shape, texture and colour, together with individual variations in vigour, control the percentage of first grade heads, and as much as 100 per cent. difference has been shown between one pedigree stock and another in this respect. Size of head has been found to be a secondary character dependent partly upon the quality and vigour characters already mentioned, and partly upon cultural considerations.

(iii) *Trueness to period of maturity for a range of varieties.*—Commercial Roscoff varieties tend to mature in late February and March. The characters of earliness and lateness appear to be complex, and only certain inbred pedigree stocks have so far been found with the capacity to mature regularly on dates outside the period mentioned. 30th December and 25th April are the most extreme mean dates of pedigree stocks and certain of these stocks are being used to furnish seed for distribution to growers.

Whereas the Cornish stocks of different maturity period have been found to be related, and to form a consecutive series for rotational cutting, the commercial early Roscoff varieties have proved to be totally unrelated to the original Roscoff seed distributed in 1924. Consequently, continuous cutting is rarely possible with early commercial Roscoff varieties.

(iv) The capacity to resist short periods of frost has been found to vary greatly between various pedigree stocks. Length of leaf and firmness of curd appear to be correlated with this resistance.

(v) *Disease resistance.*—The Ring-Spot fungus (*Mycosphaerella brassicola*) attacks d'Angers and Italian varieties very severely in West Cornwall but most Roscoff stocks are highly resistant. Data have been obtained from field trials indicating considerable differences between pedigree stocks in their susceptibility to " Finger and Toe " disease.

Title of paper issued during the year.

Report on trials of pedigree stocks, mass selections and commercial varieties of Roscoff Broccoli, 1932-33. Seale-Hayne Coll.

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148. MARSH SPOT IN PEA SEEDS

South-Eastern Agricultural College, Wye

In conjunction with the Kent Education Committee, an investigation of the occurrence of marsh spot in relation to soils in the largest culinary pea seed-growing area in Kent was carried out.

The soils of 80 fields were surveyed by means of borings, using the method employed in the United States of America. The lime-content and the amount of available potash were also determined. Some of the seed about to be sown on the 80 fields was saved for use in comparing the amount of marsh spot present with that found in the seeds of the resulting crop. A part of the original seed (55 of the 80 samples) was used for sowing in rows side by side on one field at Wye; the crop was harvested and the amount of marsh spot is being determined.

One hundred and sixteen random samples of pea pods were taken, at harvest but before carrying, from the different soils found on the 80 fields; the pods were further dried and were then threshed. The seeds are being examined for marsh spot. The results so far obtained indicate that marsh spot was common in 1933 but was not to be associated with any particular soil series within the seed-growing area. It was absent or very rare in pea seeds grown on soils of the neighbouring higher lands.

Further analysis of results is necessary before arriving at definite conclusions.

149. VARIETIES OF BRITISH FLORA

Potterne Biological Station

Anagallis arvensis.—The work with this species is being carried on, the problem being the genetics of the inheritance of colour and leaf shape. Many F_1, F_2 and F_3 generations were scored, involving hundreds of plants, and further crosses were made. A new colour segregation appeared for the first time in 1933, this has been used in the new crosses; *A. foemina* has also been used. In some generations there was, in 1933, complete sterility.

Centaurea.—Thirty-five F_2 generations of hybrid origin made under control, containing about a thousand plants, were scored. Much further work has still to be done before complete data are obtained; at present it is estimated that another six years' research will be necessary. No plants are scored until the second year from seed as only a proportion flower the first year. There are seventy-two generations to be scored this year containing about two thousand plants.

Eighty-four selfings and crosses were made with F_1 plants of hybrid origin in 1933, *Jacea, jungens* and *pratensis* crossed *nemoralis* and *nigra*. Further selfings and crosses of F_1 plants will be made this year.

Ononis.—In 1932 *Ononis spinosa* was selfed, and in 1933 the var. *mitis* was also selfed. *Ononis* will probably be used in the Transplant Experiments at a later date. This work is being carried out to determine if the plants used are genetically pure.

Ranunculus.—The work continues with *R. Ficaria* and *R. acris* with regard to sex and colour.

Saxifraga.—The research with *Saxifraga* was finished in 1933. The original cross was *S. rosacea* x *granulata* and the reciprocal; further, many reciprocal back crosses were made with plants of the F_1, F_2 and F_3 generations. Forty-eight generations have been made, containing four thousand four hundred and seventy five plants, the number grown to the flowering condition; these were all examined and their characters recorded at all stages of their life history. The cytological investigation carried out by J. Philp of the John Innes Horticultural Institution, Merton, is completed.

Silene.—Eight generations were scored. The research last year completed the investigation of the inheritance of colour in the vegetative parts of *S. vulgaris*. A plant with vivid green shining vegetative parts was crossed with a plant with dull green non-shining vegetative parts. The vivid green plant was glabrous and the dull green densely hairy. The F_1 generation was dull green and hairy. Many other characters were studied such as capsule shape, colour of immature seeds, pattern of mature seeds, etc.

Solanum.—*S. Dulcamara* var. *marinum* was selfed in 1932 and a generation raised to ascertain its status; the plants will be scored this year.

Transplant Experiments.—These have brought out clearly the different reactions or lack of reactions of the species being used, and the complexity of a plant's environment.

The following species are at present under observation, *Centaurea nemoralis forma radiata albiflora*, *Silene maritima*, *Plantago major*, *Anthyllis Vulneraria*, *Fragaria vesca*, *Phleum pratense*, diploid and *Phleum pratense*, hexaploid.

Titles of papers issued during the year.

1. Marsden-Jones, E. M., and Turrill, W. B.: Second Report of the transplant experiments of the British Ecological Society at Potterne. *J. Ecol.*, **21**, 268, 1933.
2. ————: Studies in variation of *Anthyllis Vulneraria*. *J. Genet*, **27**, 261, 1933.
3. ————: Notes on the taxonomy of British material of *Anthyllis Vulneraria*. *J. Bot.*, **71**, 207, 1933.
4. ————: A statistical study of characters in two wild publications of *Silene maritima*. *Roy. Bot. Gdns., Kew: Bul. Misc. Inf.*, No. 10, 479, 1933.
5. Marsden-Jones, E. M.: *Ranunculus Ficaria*. *Proc. Linn. Soc., 1932-33*, 118, 1933.

150. WORM INFESTATION OF SHEEP

Aberdeen: North of Scotland College of Agriculture

In last year's report mention was made of the losses to the sheep industry in several counties as a result of internal parasites. Examination of the infested sheep proved that as many as nine different species of worms were usually present, the chief offender being the lesser stomach worm (*Ostertagia circumcinta*). Often variations occurred, however, particularly with regard to numbers and resistance to the effects of infestation, and it was clearly evident that the practical value of this investigation would be greatly enhanced if it were extended to include the whole of Scotland. The survey already commenced in the summer of 1932 was therefore widened to include every county in Scotland, as a joint investigation between the North of Scotland College of Agriculture and the Rowett Research Institute.

To expedite the survey work questionnaires were sent to 857 breeders of pure Border Leicester, Cheviot and Blackface flocks and 768 breeders of commercial sheep. Of the 545 completed questionnaires received 295 reported losses from suspected worm infestation. Although it will be impossible to call on every farmer experiencing trouble, it is hoped that at least 75 will be visited for the purpose of collecting material. 29 farms have already

been visited in the counties of Ayr, Wigtown, Kirkcudbright, Dumfries, Lanark, Caithness, Sutherland, Inverness and Ross, and a total of 15 infested sheep autopsied for the purpose of collecting the worms harboured.

Titles of papers issued during the year.

1. Fraser, A. H. H., and Robertson, D.: The influence of the nutritional state of the sheep and its susceptibility to infestation with the stomach worm, *Haemonchus contortus*. *Emp. J. Exp. Agric.*, **1**, 1, 17-21, 1933.
2. ————: On the incidence of stomach worms in lambs in the North of Scotland and their control by progressive sectional grazing. *J. Helminth.*, **11**, 4, 187-194, 1933.
3. Robertson, D.: Worm infestation of lambs. *Scott. J. Agric.*, **16**, 3, 320, 1933.

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151. INFLUENCE OF FEEDING ON THE COMPOSITION OF THE BLOOD AND MILK OF DAIRY COWS

Dr. J. F. Tocher

The object of the investigation is to determine the factors which affect the quality of milk, in order that those factors shown to have a beneficial effect could be applied practically to herds throughout the country.

During the past year experiments have been carried out on the relation between the feeding and the composition of the milk and blood of two groups of cows, one group giving deficient milk, the other group giving milk which conforms with the required standard of fat and solids-not-fat. A group of cows, giving deficient milk, have been given rations varying in the amount of protein, carbohydrate and minerals and the effect of these different rations has been studied. From work done during the first two years of the investigation it was found that cows, giving deficient milk, which had been fed on a bare winter ration showed an increase in milk yield and solids-not-fat content of the milk when fed on an adequate winter ration. This increase was noted also when the cows were changed over from winter rations to summer rations on grass. The increase produced was not large enough to bring these deficient milks up to the presumptive limit of 3·00 per cent. butter fat and 8·50 per cent. solids-not-fat.

Following on some preliminary experiments with feeding a large proportion of protein in the ration, the group of " poor " cows were fed on a high protein ration, of albuminoid ratio 1 :2·50, for a prolonged period. As a result of this the solids-not-fat content of the milk was decreased, but the milk yield, fat and ash content remained unaltered. From the results of other workers on cows giving normal milk it was anticipated that the high protein would increase the milk yield. During the high protein feeding the

total nitrogen content of the milk increased. This increase was shown in an increase in the albumin and globulin and non-protein nitrogen. The casein portion showed no change. The most striking result of the experiment was the decrease in the lactose content of the milk brought about by the high protein in the ration. The lactose content has been shown by other workers to remain constant during changes of the protein content in the diet. It has been shown previously that as the lactose percentage decreases the albumen and globulin concentration increases. It would seem that the decrease of lactose has been brought about indirectly by the high protein ration through the increase in the total nitrogen and the albumin and globulin nitrogen.

From preliminary experiments the fat content of the milk was increased by a high carbohydrate ration. If such an increase could be maintained along with an increase in the solids-not-fat content and no decrease in the milk yield our problem would be partly solved. As a result of feeding a high carbohydrate ration, with a wide albuminoid ratio of 1 :10·0, for a prolonged period, both the fat and lactose percentages of the milk were increased. There was no change in the milk yield, ash or albumin and globulin content, while the solids-not-fat, total nitrogen and casein percentages were decreased. The increase of carbohydrate in the ration has been instrumental in raising the lactose but has also lowered the protein content to such a marked degree that the total result has been to lower the solids-not-fat content.

Feeding additional minerals in the form of steamed bone flour produced no significant change in the fat, solids-not-fat and yield of the milk and only a very small increase in the ash content. Vitamin D was given in small doses in the food of the cows but no change, beneficial or otherwise was found to occur in the composition of the milk. There is no doubt, however, that the quality and yield of the milk of the " poor " cows have improved since the purchase of the cows. This is the result of adequate feeding during a prolonged period to cows which, previously, had been undernourished.

The composition of the blood of the two groups of cows has been studied. Both groups of cows have been kept under the same conditions of feeding and environment. The differences in the composition of the blood of the two groups were very small. The group of good milkers showed a very slightly higher inorganic phosporus and serum calcium content in the blood than the group of poor milkers. The milk of the good milkers had a higher lactose percentage than that of the poor milkers, but the blood sugar level was very slightly lower in the group of good milkers. None of these differences was great enough to show a significant difference between the two groups because the daily variations in these blood constituents were very wide. The statistical examination of the blood data is now being carried out.

A long series of determinations on the vapour pressure, both of the blood and the milk, has been carried out on the samples submitted to chemical analysis. The investigation on the many problems involved is being continued conjointly from the statistical, chemical and physical standpoints.

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152. INVESTIGATION ON THE METABOLISM OF SHEEP, WITH SPECIAL REFERENCE TO SCRAPIE

Pharmacological Laboratory, Edinburgh University

A study was made of the metabolic rate of the scrapie sheep as compared with that of the normal, since previous work indicated that there was an enlargement and hyper-activity of the thyroid gland. A metabolism chamber suitable for use with sheep was constructed and the oxygen consumption and carbon dioxide production were measured.

Before commencing it was necessary to procure a suitable standard of comparison. As is well known, scrapie is not commonly seen until the animal has reached two years of age, and it was therefore necessary to obtain as controls sheep which were two years old or over, so that with the exception of the disease there were as few extra variables as possible. Six healthy normal sheep three years of age were obtained since this was about the average age of the scrapie sheep under investigation. These controls were grazed on pastures strictly comparable to those upon which the scrapies were grazed. No mixing of the two groups was allowed nor were the controls permitted to graze on the pasture used by the scrapies, all received in addition 1·75 lb. of a mixture of oats, etc., per day.

The results indicated that there is no demonstrable difference between the metabolic rates of normal and scrapie sheep.

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153. STRINGHALT, SHIVERING, AND ALLIED CONDITIONS IN THE HORSE

Edinburgh : Royal (Dick) Veterinary College

Further work has served to confirm previous conclusions that there are many conditions in the horse at present regarded as separate distinct diseases which are merely localised conditions of one generalised inflammatory disease, liable to affect numerous tissues of the body.

Bones, joints, and the peripheral nervous system, show constant signs of the disease, but many other tissues of the body suffer.

Where the peripheral nervous system is grossly damaged by the general disease, then the permanently disabling conditions of incoordination of various muscle groups occur. Such conditions as shivering, partial paraphlegia, stringhalt, grunting (probably also roaring) arise in this way. At the same time any horse showing one or more of these nervous disabilities will always have bone and joint lesions to a greater or less extent. A brief summary and discussion of the general findings has been published (1).

A complete post-mortem investigation has been made of two horses this year, one suffering from shivering and the other from partial paraphlegia.

Partial post-mortem investigation has been made of numerous horses suffering from osteo-arthritic lesions, such as navicular disease, ringbone, sidebone, etc., many of the specimens being sent by veterinary surgeons.

The complete skeletons and portions of fresh material taken from all the chief tissues of the body of all the horses considered in the tables in the publication noted below are in the possession of the College, and with this mass of material for comparison, macro- and microscopically, there is still much to be done.

Now that the general pathology of this group of disease conditions is clearer, and in view of the restricted nature of the diet of horses (oats and hay), an experimental study from a dietetic point of view would be desirable.

Title of paper issued during the year.

1. Mitchell, W. M.: Some aspects of the general osteo-arthritic problem in the horse. *Vet. Rec.*, 23rd September, 1933.

154. BACTERIAL FLORA IN COWS MILK

Glasgow : West of Scotland Agricultural College

The effect of different conditions on the estimations of the bacterial content of milk by the plate method were investigated. It was found that the shaking method prescribed by the Ministry of Health for such estimations was satisfactory for the distribution of the clusters of fat globules throughout the milk, but it was not sufficient to break up the clusters and disperse the organisms in contact with them. There seemed, however, to be little advantage to be gained by prolonging the period of shaking by hand. While homogenisation increased considerably the values of the mean counts of samples of milk, it had little influence on the uniformity of parallel plate counts in the case of comparatively fresh samples.

Of 797 strains of coliform bacteria isolated from samples of milk throughout the year, 54·2 per cent. were of *B. coli* types, 15·7 per cent. of *B. lactis acrogenes* types, and 9·3 per cent. were of

B. cloacae types. The remainder were intermediate in type. When the cows were confined to the houses (in winter) 71 per cent. of the strains isolated from the milk were of *B. coli* types, but when the cows were at pasture (in summer) only 40·4 per cent. were of these types.

Title of paper issued during the year.

Malcolm, J. F.: The plate method of estimating the bacterial content of milk. *J. Dairy Res.*, **4**, 1, December, 1932.

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155. BRACKEN INVESTIGATION

Glasgow : West of Scotland Agricultural College

The work in the field has been continued and a paper on the effects of sodium chlorate on bracken has been published (1). The advantages of this chemical, which can give a quick kill, are compared with the slower but more economical methods of cutting. Experimental evidence is brought to bear on the question of the ignition danger due to the use of sodium chlorate. A paper in the press deals with the spread of bracken and an examination of the limiting factors, some of which have ceased, or are rapidly ceasing, to exist. Another paper in course of preparation attempts to classify the appearance of the bracken diseases met with during the investigation.

The entomological investigations are being continued by the zoologists who are co-operating.

Title of paper issued during the year.

Braid, K. W.: Herbicides, with special reference to sodium chlorate and its effect on bracken. *Scott. Farmer*, **41**, 1484, 1933.

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156. GENETICS, CYTOLOGY AND TAXONOMY OF THE GENUS *ROSA*

Dr. C. C. Hurst

No new genetical and cytological material was raised during the year under review and efforts were concentrated in utilising the existing material to the best advantage.

In the new classification of the tribe, four old genera have been revived and two new genera have been set up in addition to the original *Rosa* of Linnaeus. These have been established on experimental genetic and cytological evidence.

The classification of the genus *Rosa L.* is based on the five primary sections of the diploid Linnean species, each section of

Linnean species representing a genetical species. The remaining sections of Linnean species represent polyploid hybrids of the primary sections. The largest section of polyploid species, *Caninae*, which has been difficult to classify since the time of Linnaeus, falls into line when classified by the gene content of its bivalent chromosomes, each paired septet or genome representing a diploid genetical species. During the year the following results among others have been obtained in the maturation of the genetical material :—

(i) The small batch of F_2 generic hybrids between *Rosa rugosa* and *Platyrhodon microphyllum* have produced several flowers but no seeds have set. Two of the plants show the characters of *Rosa* only and have pure white flowers like the grandparent *Rosa rugosa*. One dwarf unflowered plant shows so far only the characters of *Platyrhodon*. The remainder appear to be intermediate between the two genera and two of these have produced pale pink flowers like the F_1 parent. A few plants of the F_1 back-crossed with *Rosa* have been raised, and also F_1 of *Platyrhodon microphyllum* x *Rosa macrophylla*.

(ii) Plants of the F_2 generation of a hybrid between *Rosa Arvensis* of Europe and *R. Soulieana* of Western China have been raised and have segregated into two distinct types of stems and leaves resembling the original parents.

(iii) Five of the F_2 generation of the tetramerous *R. sericea* x the pentamerous *R. Hugonis* have flowered. Three plants bear flowers some of which have five sepals and petals and others four. Two plants have borne pentamerous flowers only, and none has yet appeared with tetramerous flowers only. Only one plant of the F_1 generation was raised and that bore pentamerous flowers only. Two plants of the back-cross to the tetramerous recessive have flowered and both appear to be pentamerous.

(iv) A large batch of the F_1 *R. multiflora* x *R. Coryi* have flowered which show Mendelian segregation in the colours of the stems and fruits. All the hybrids are climbers like the parent *R. multiflora*, the other parent being a dwarf only a few inches high.

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157. SHEEP MAGGOT FLY INVESTIGATION

Natural History Department, University of Aberdeen and Rowett Research Institute

Species responsible for "Strike".—The work carried out during the year was limited to the area immediately around Aberdeen and maggots and eggs were collected from eight different localities during the period when they first appeared in the flocks in the area. With one exception, a batch of maggots from

Strathdon from which were bred out a number of *Calliphora erythrocephala*, they turned out to be *Lucilia sericata*.

Nature of "Strike".—A study of the occurrence of "strike" last summer indicated very definitely the following points:—

(i) The abundance of flies was such that any and every sheep might have been struck and by many flies;

(ii) Some peculiar attraction in certain individuals (in many cases a dirty tail due to scouring) leads to one or more flies striking;

(iii) The pathological effect of the maggots feeding on or over the skin greatly increases the attraction to the flies, and a large number of flies will then strike the sheep, on or near the inflamed area.

In their replies to the questionnaire circulated by the Department, a number of farmers stated that there were certain individual sheep in their flocks which seem predisposed to maggot attack. In some cases they were visibly "weakly" (an animal which is not thriving is apparently always more liable to be struck than a healthy individual) but in others this was not so. Moreover a sheep struck in one year was particularly liable to be affected the following season.

Treatment of struck sheep.—Beyond observing the methods practised (and their effects), little was attempted under this head in 1933. Although the ideal dressing has not yet been discovered, enough is known of the properties of the various substances available for use to suggest better treatment than most sheep are in the habit of receiving.

The difficulties in the way of suggesting suitable dressings are the following:—

(i) Shepherds like to see the maggots killed in the fleece. A dressing strong enough to do this rapidly is inevitably irritating to the skin of the sheep—a very serious fault;

(ii) Shepherds like single dressing, which can be used for all cases; and one that is easily and cheaply made up;

(iii) A dressing should not stain or "lift" the wool;

(iv) So far as is known very few substances have a definite repellent action to the flies, preventing a second strike.

A short trial was made with a dressing recommended by the South African Department of Agriculture. The indications were that it was likely to prove effective; but might have the drawback of staining the wool. It is proposed to carry out next year a properly controlled trial, if the co-operation of flock owners can be obtained.

Breeding experiments.—These were carried out in the laboratory and much useful data secured. It was found that at a temperature of 80° Fahrenheit batches of eggs hatched, without exception, in

under 24 hours. At room temperature about 36 hours seemed to be the period.

It is the belief of shepherds that eggs laid in the wool may hatch in 12 hours. The times observed did not support this theory.

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158. METHODS OF CONTROL OF THE RASPBERRY AND LOGANBERRY BEETLE AND THE USE OF TUBA ROOT (*DERRIS ELIPTICA*) AS AN INSECTICIDE

East Malling Horticultural Research Station

Control of Raspberry Beetle.—Field spraying and dusting trials were carried out on raspberries, loganberries and blackberries and their results have already been published (1). These trials showed that a satisfactory degree of control can be obtained both on raspberries and on loganberries with a single application of a Derris spray, given when the larvae begin to damage the berries (normally late in June). This possibility had already been foreshadowed (2). Evidence was again obtained which confirmed previous seasons' trials (2, 3) that a Derris and soap spray of 0·005 per cent. rotenone content is highly toxic to the larvae of this pest.

Further, it was shown that a great deal of latitude can be allowed in timing the spray—a matter of great importance in commercial practice. On loganberries it was found that the effectiveness of control measures could be improved as regards the later pickings of fruit by giving an additional spraying shortly before picking begins, but, from a commercial point of view, this extra spraying could scarcely be justified.

Inconclusive results were obtained in an experiment on raspberries designed to test the value of a Derris dust containing 0·1 per cent. rotenone against the adult beetle.

Further small trials on different varieties confirmed the previous seasons' finding (3) that the pest can be controlled on cultivated blackberries by means of Derris and soap, and suggested that for these crops also a single spraying may prove adequate.

Derris Root as an insecticide. Laboratory tests.—Biological tests are being carried out in collaboration with Rothamsted. A start has been made with the testing on standard test insects (such as Vapourer Moth larvae and the aphids *Myzus persicae* and *Aphis pomi*) of samples of ground root and of extracts of these supplied by Rothamsted. Many difficulties of technique, etc., have been experienced and it is evident that this part of the work will entail long and careful research. The object is to correlate the toxicity of Derris with its chemical and physical properties and so pave the way for the commercial standardisation of Derris preparations.

Field spraying trials.—Derris was used in spraying trials against various insect pests. These trials were wherever possible made the subject of close collaboration with other investigators engaged at East Malling in studying the same or similar problems from other angles. Derris was usually used in comparison with standard spray mixtures and sometimes in comparison with entirely new spray materials.

The value of Derris as an ingredient in mixed washes for use in a normal apple spraying schedule was investigated in a collaborated trial. By means of such trials information is being collected as to the value of Derris in various " combination washes " and of the relative merits of various wetters and spreaders for use with Derris.

Titles of papers issued during the year.

1. Steer, W.: Studies on *Byturus tomentosus* Fabr. IV. 1933. Experiments on the control of the raspberry and loganberry beetle. *J. Pom. and Hort. Sci.*, **11**, 188-196, 1933.
2. ————: Studies on *Byturus tomentosus*. Fabr. III. *Ibid.*, **11**, 19-38, 1933.
3. ————: Further observations on the habits of the raspberry beetle, with special reference to the control of the pest by means of Derris. *Ibid.*, **10**, 1-16, 1932.
4. ————: The raspberry and loganberry beetle and how to control it. *East Norfolk Fruitgrowers' Assoc. Yr. Bk.*, 85-87, 1933.

APPENDIX.

LIST OF DIRECTORS OF RESEARCH INSTITUTES, ETC., AND HEADS OF ADVISORY CENTRES.

I. RESEARCH INSTITUTES, ETC.

A. Soils, Plant Nutrition and Plant Physiology.

Sir E. J. Russell, O.B.E., D.Sc., F.R.S.
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Prof. V. H. Blackman, Sc.D., F.R.S.
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B. Plant Breeding, Crop Varieties and Seeds.

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I. Agricultural Economics.

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J. Preservation and Transport.

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